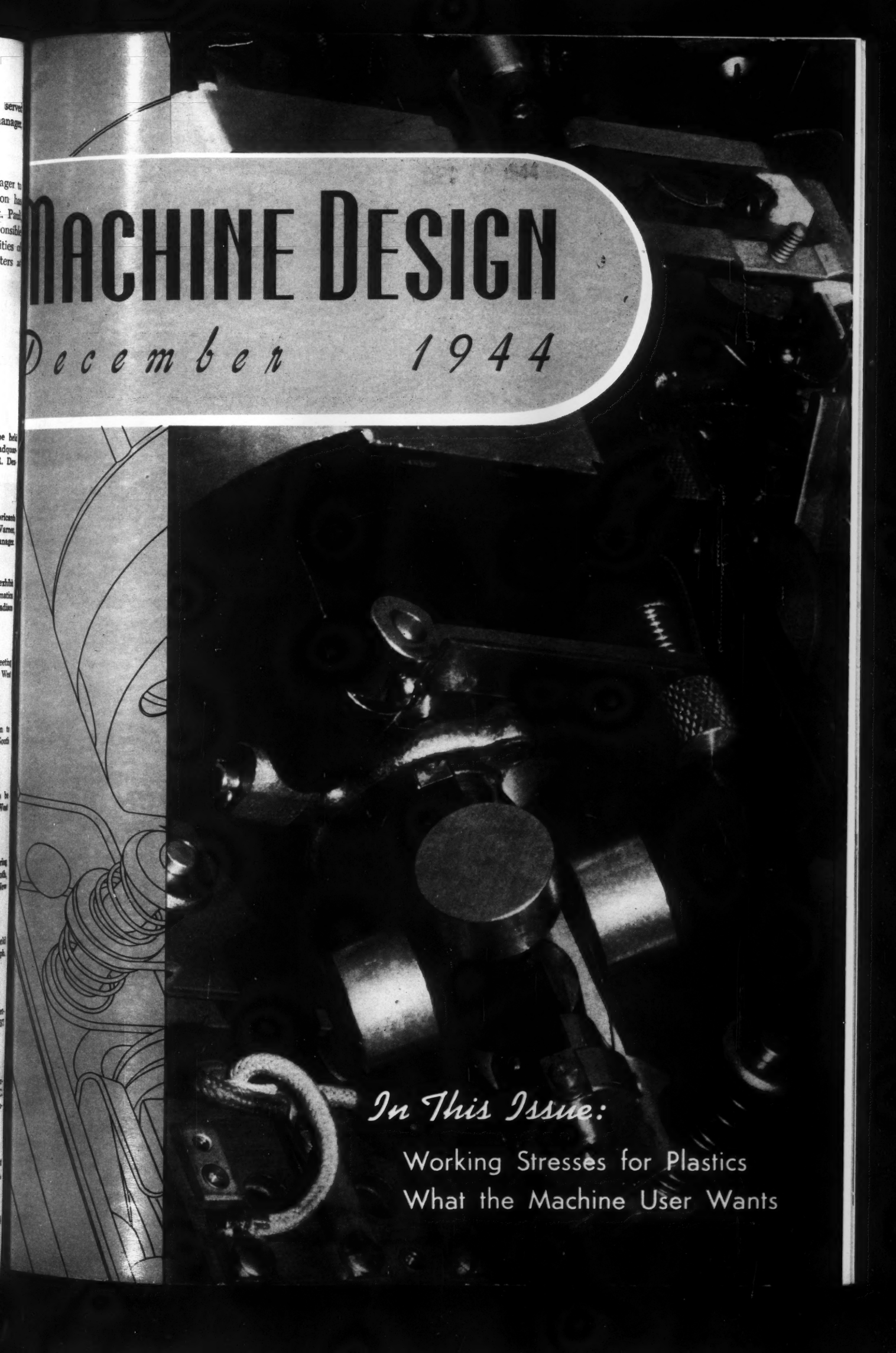

MACHINE DESIGN

December 1944

In This Issue:

Working Stresses for Plastics

What the Machine User Wants

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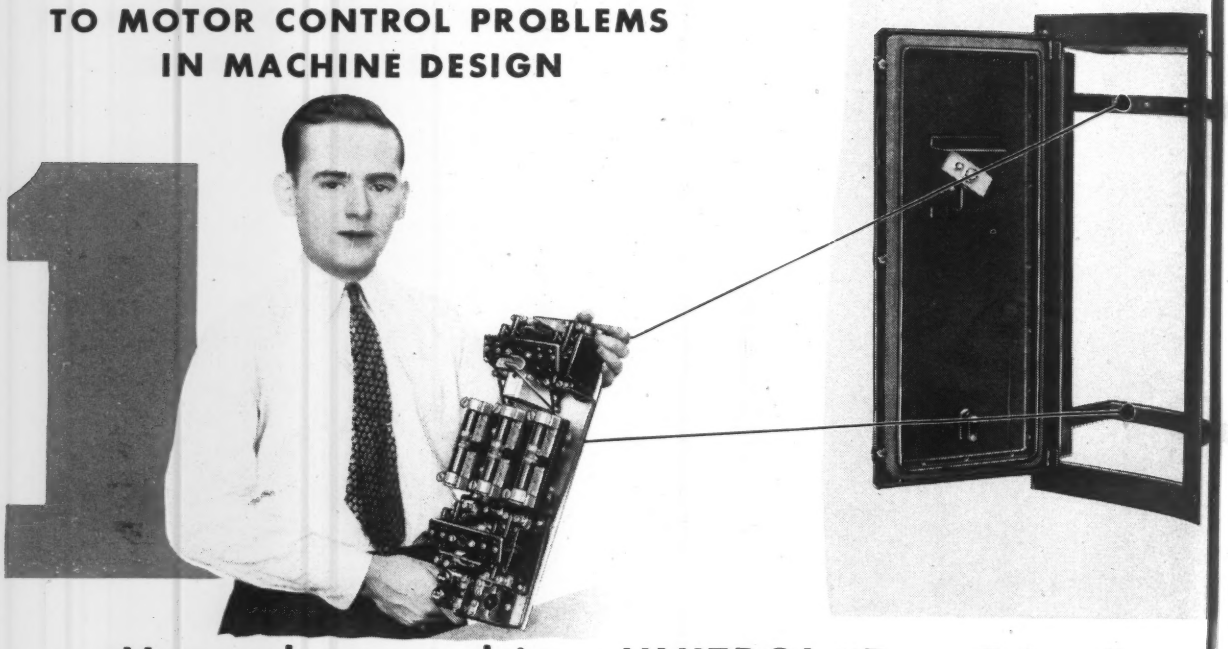
TO MOTOR CONTROL PROBLEMS IN MACHINE DESIGN



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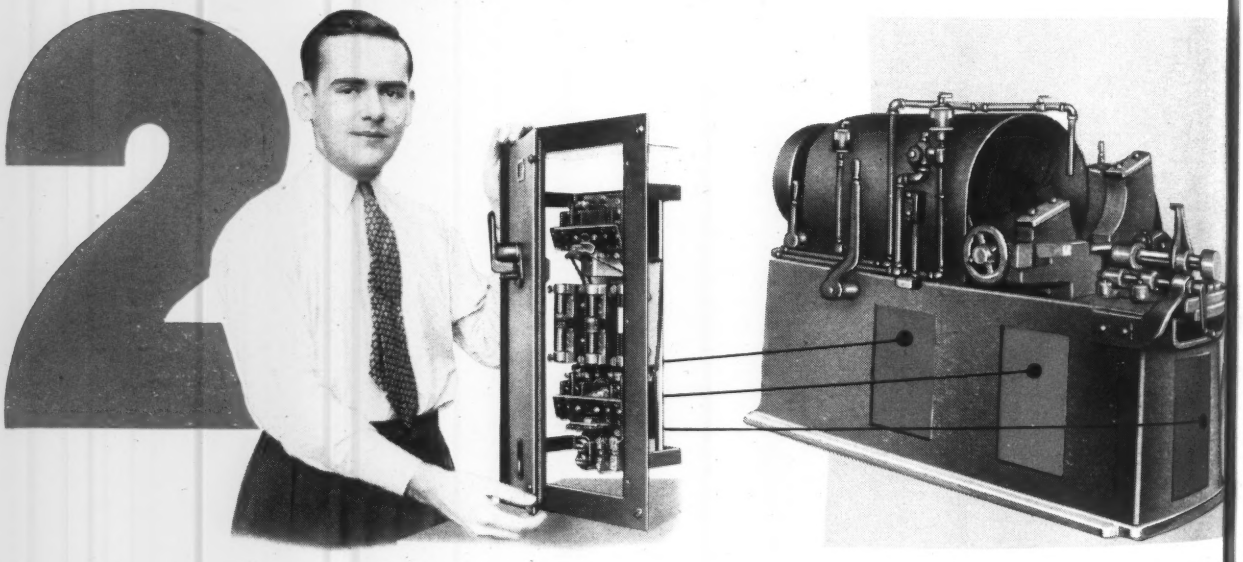

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THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

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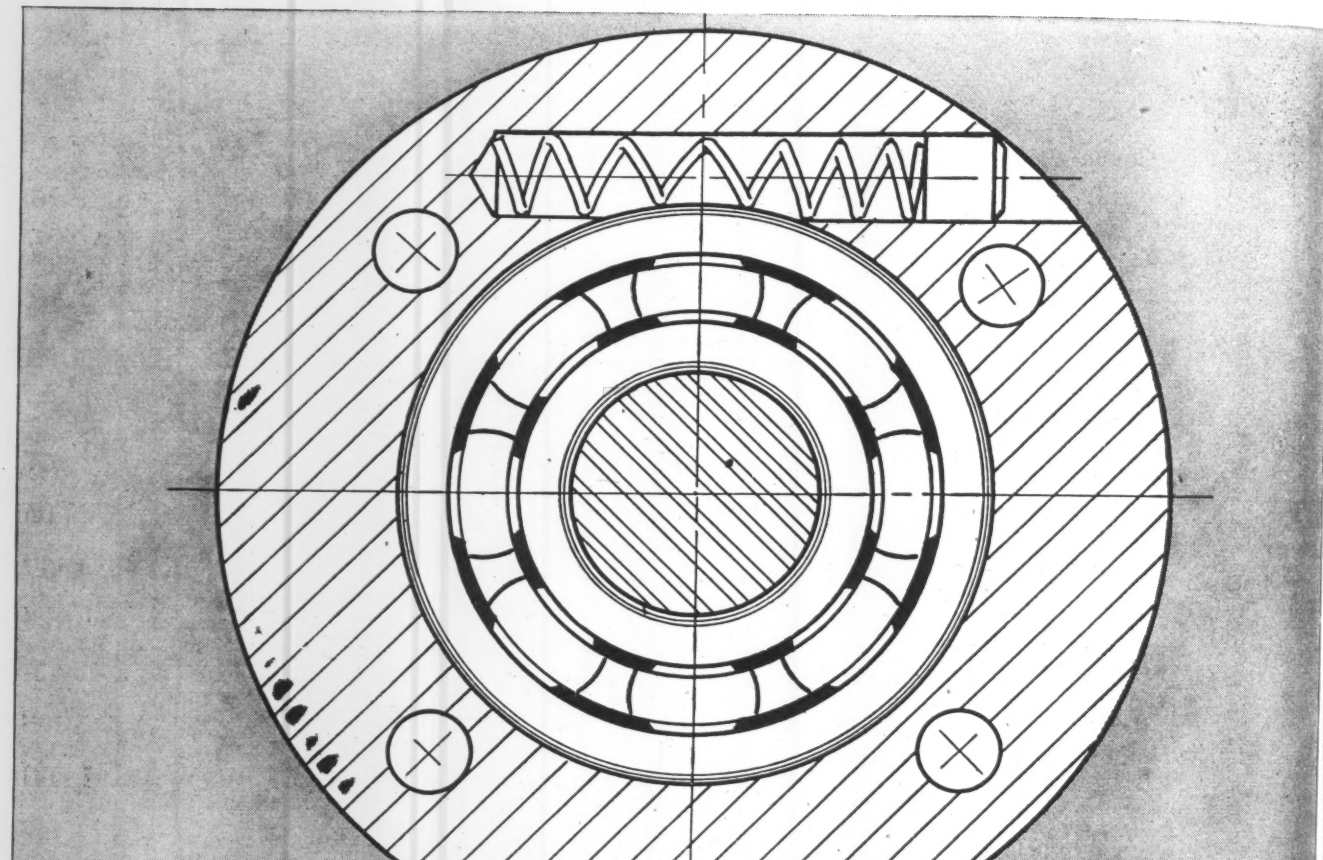
A Bearing Tip . . .
for your design notebook



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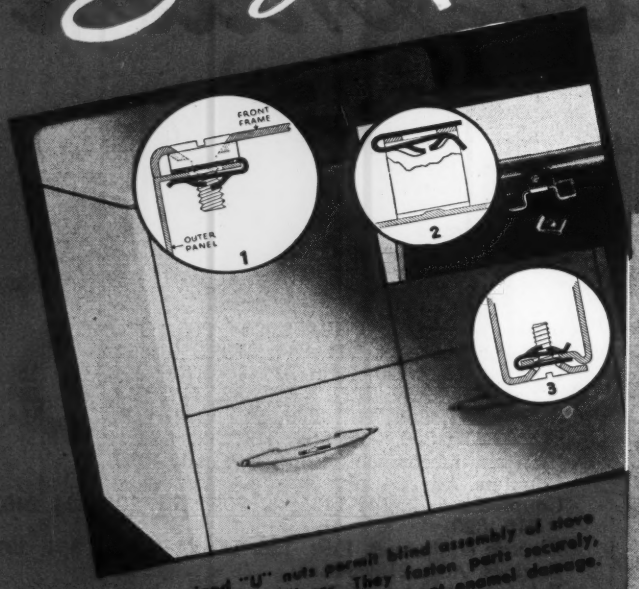
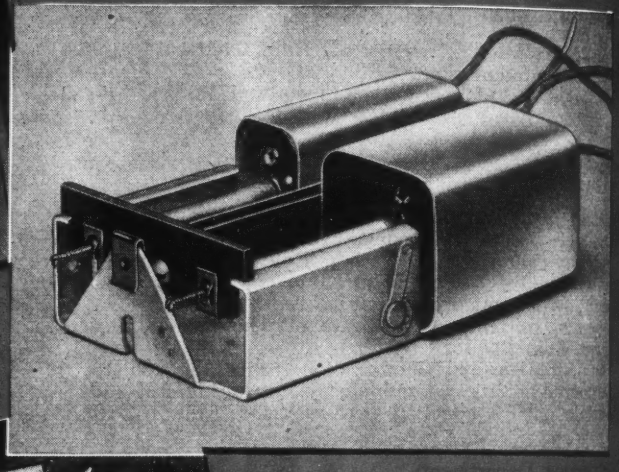
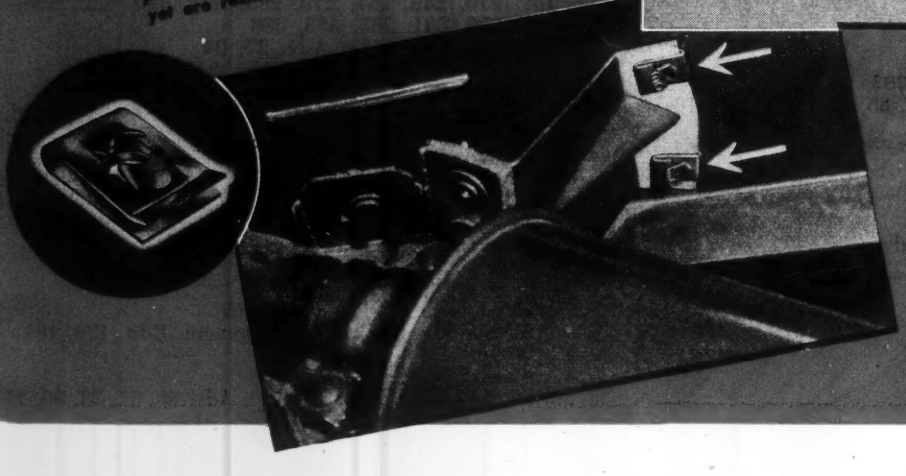


Self-retained "U" nuts permit blind assembly of stove panels and door liners. They fasten parts securely, yet are resilient enough to prevent enamel damage.





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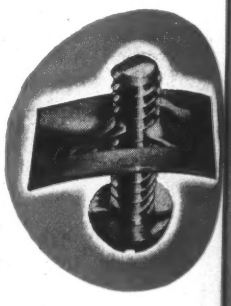

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FASTEST THING IN FASTENINGS

This issue at a glance

How Much "Real Muscle" Do Plastics Have?

. . . . In other words, what working stresses will they take in actual applications? There are many influencing factors. Heat, humidity, chemical action, and manufacturing inconsistencies are some of them. Here's important reading for the designer of plastic machine parts. Page 99.

What Does the User Want in Machines?

. . . . Also, what doesn't he want? Some things he'd like to have are automatic bearing lubrication, hardened and ground ways, and convenient, safe controls. He doesn't want motors built-in so snugly they can't be lubricated or serviced. If you're interested in what the customer has to say, don't miss the article beginning on Page 147.

X-Ray Inspection of Machine Parts . . . .

. . . . is nondestructive, reduces service failures. Known as radiography, it can do much to point the way to better design of castings, forgings and welded structures. Just what do structural flaws look like in radiographs and what do they indicate? See Page 135.

Lighting Will Be Custom Tailored . . . .

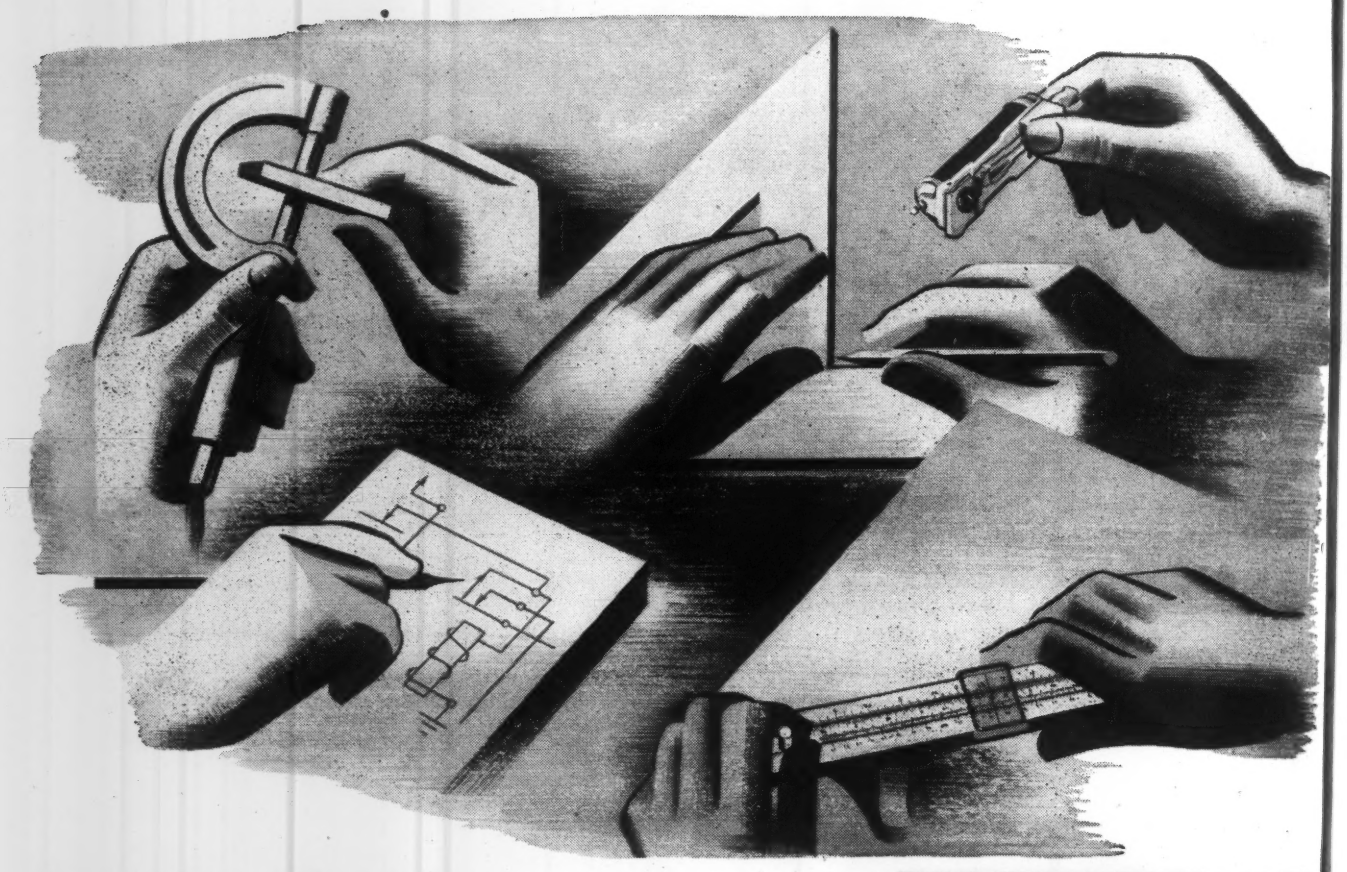
. . . . into machines of the future. It'll be built-in—out of the way—and focused to flood work-areas. All this points to curtailment of operator fatigue, greater convenience and higher output. Turn to Page 107 for an up-to-the-minute discussion of this important subject.

Predicting the Ultimate Strength of Machine Parts . . . .

. . . . involves plastic theory, not elastic theory. So says Leon Beskin in his article commencing on Page 117. You'll want to get the facts on this departure from commonly employed methods of stress determination.

Hydraulics Fills the Bill . . . .

. . . . in many machines where numerous complex motions are required with precise control. Why and how hydraulics was used to power and control a modern cylindrical grinder is the subject of F. A. Firnaber's interesting article starting on Page 153.



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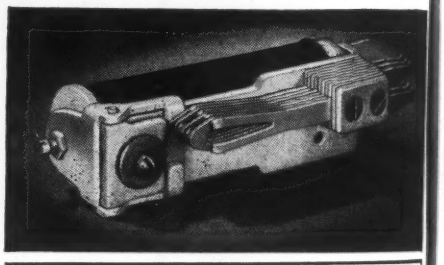

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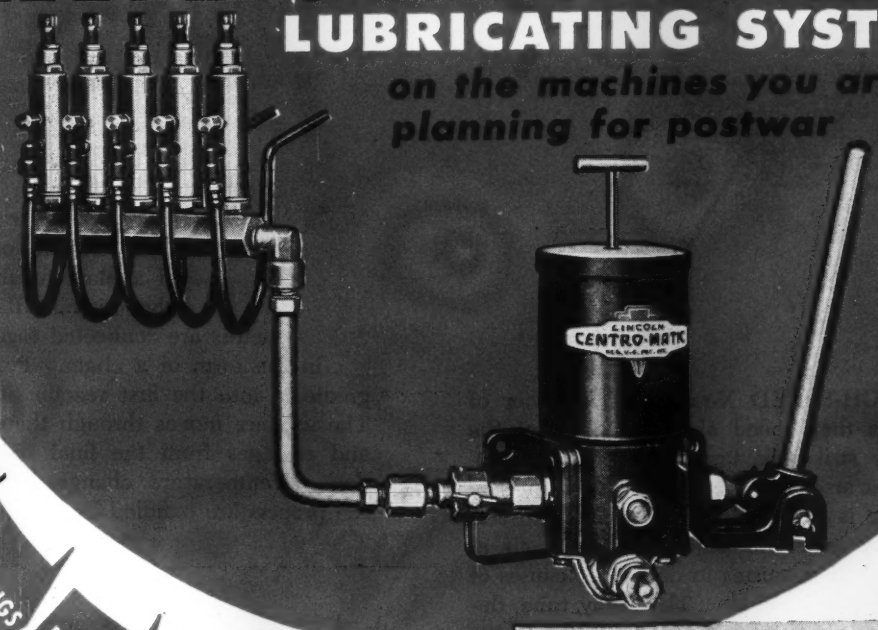

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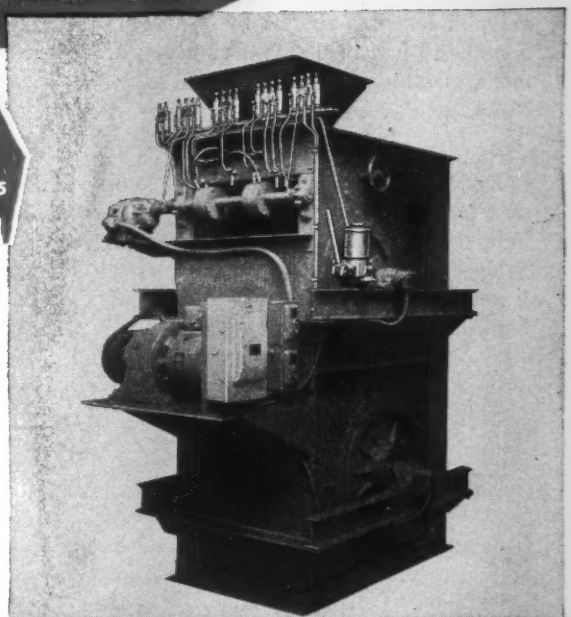

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ULTRA-HIGH-SPEED X-raying of behavior of bullets as they speed along the bore of the gun or as they strike the target has been of inestimable value at arsenals and proving grounds. The same procedure is expected to be extremely useful in studying the action of machine parts such as valves and other mechanisms to determine causes of unnecessary wear and failure. The X-ray tube, developed for such studies by Westinghouse, requires a sudden burst of 600,000 kilowatts of electricity to make a millionth-second exposure.

DAYLIGHT READINGS of cloud ceilings can now be taken accurately with the aid of a pulsating light system and a photoelectric detector. Developed by Lawrence W. Foskett, U. S. Weather Bureau, in conjunction with General Electric, the device measures clouds as high as two miles.

WELDED SEAMS in pressure vessels are readily tested for leakage by spraying them with a creeping, penetrating chemical with an extremely low surface tension so it spreads and creeps rapidly. In tests this chemical, known as Kano Kroil, has been shown to penetrate a .000001-inch space.

DEVELOPMENT of a fuel-injection two-cycle engine rivaling the diesel in power and economy is a possibility in the not-so-distant future. According to H. O. Hill of American Bosch Corp., "Economies which are inherent in the construction of engines operating on the two-stroke-cycle might do more than offset the cost differential between gasoline injection equipment and the carburetor."

CONTINUOUS POLYMERIZATION process, developed by Goodyear Tire and Rubber Co., in addition to increasing the production of synthetic rubber by 40 per cent reduces the original capital cost of a plant to about one per cent. In polymerizing GR-S rubber latex, reactors are connected together by pipe lines in the form of a chain. Pumps admit the ingredients into the first reactor at the proper rates. The mixture moves through the successive reactors and emerges from the final unit in a continuous flow. Temperature changes at various stages of the process are handled by a series of controls.

IN WARPLANES the present type of engine is twice as efficient as jet propulsion at 150 miles an hour, the two are equal at 300 and at 550 jet propulsion is twice as efficient.

NEW COMPOUND of nylon permits coating of electrical wire at rates of more than 1000 feet per minute. Extruded in standard equipment, nylon jackets seven mils in thickness and forty mils overall diameter have been produced at this speed, according to Dr. Shackleton of E. I. du Pont de Nemours & Co. The die used is a modified, self-centering tubing design which allows for the free flowing of the nylon, the thickness being dependent upon the wire speed.

DEVELOPMENT of a 2,000,000-volt mobile X-ray unit by G. E. doubles the voltage previously available for examination of metal sections. In radiographing an 8-inch section the outfit is 78 times faster than a million-volt unit. Further, it makes practical the examination of one-foot sections hitherto opaque to X-rays.

ALMOST SEVENTY PER CENT of the colleges and universities surveyed are making plans for teaching postwar courses in aviation. Of these schools, 77 per cent are now teaching some aspects of aviation and 69 per cent are definitely planning to continue or expand their curricula, according to a survey by Bendix Aviation Corp.

MACHINE DESIGN

How Much "Real Muscle" Do Plastics Offer the Designer?

By John Delmonte
Technical Director
Plastics Industries Technical Institute

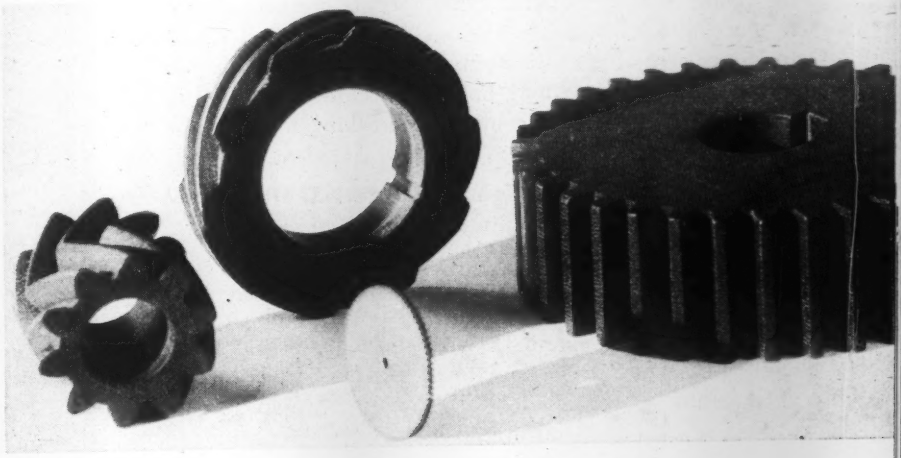


Fig. 1—Strength of plastic machine parts such as these spur, helical and herringbone gears may be affected considerably by temperature, humidity, chemical action and other factors

MANY useful data have been published upon the ultimate properties of plastics in tension, compression or shear, though few recommendations have been prepared on the safe working stresses for plastic materials. Knowledge of ultimate breaking loads is invaluable when determining the comparative merits of various plastics, hence they are widely employed in evaluating the standard characteristics of plastics. In engineering practice, most widely used specifications for the testing of plastics are the ASTM Standards and the Federal Specification L-P-406a, while one of the most useful compilations of test data appears in the recent publication of the Plastics Materials Manufacturers association (1)*. This last-mentioned reference is particularly important because it plots the physical properties of plastics as functions of the temperature.

Working stresses for plastics must reflect the influence of numerous environmental conditions upon the properties of plastics, as well as the influence of variations in manufacturing methods. It is not always easy for the designer to adjust habits of thinking acquired for the more uniformly behaving metals to plastics. However, in the successful application of plastics to stressed ma-

*References in parenthesis are listed at end of article.

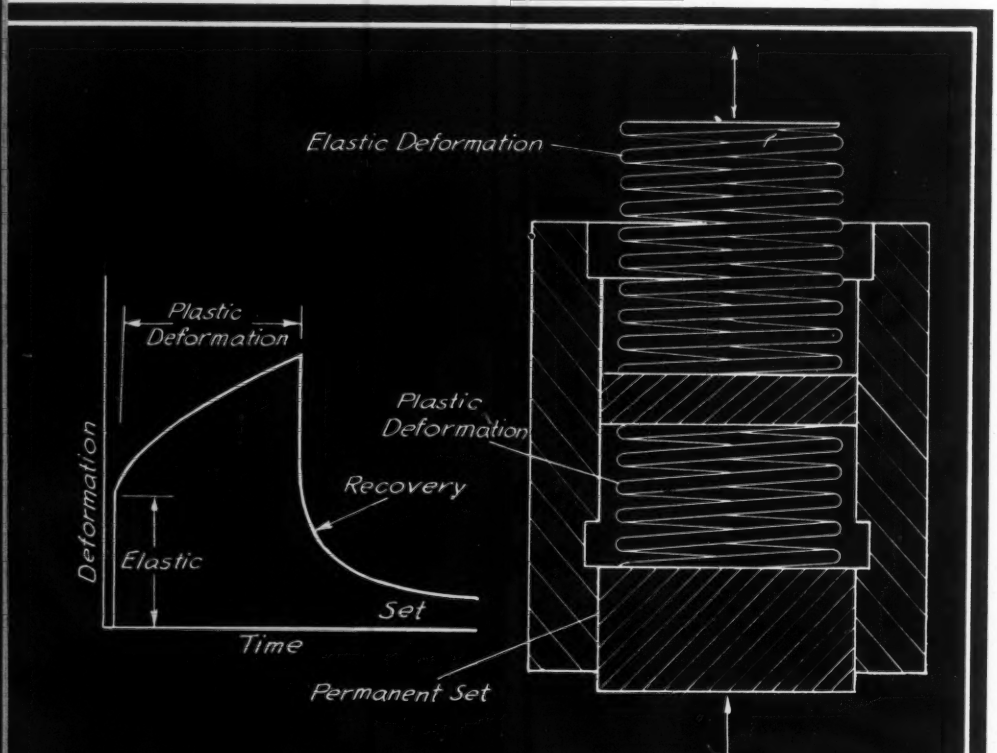


Fig. 2—Left—Model shown in cross section at the right of illustration gives mechanical analogy of the three phenomena which occur in plastic materials when placed under load. Curve at left of model shows these phenomena graphically

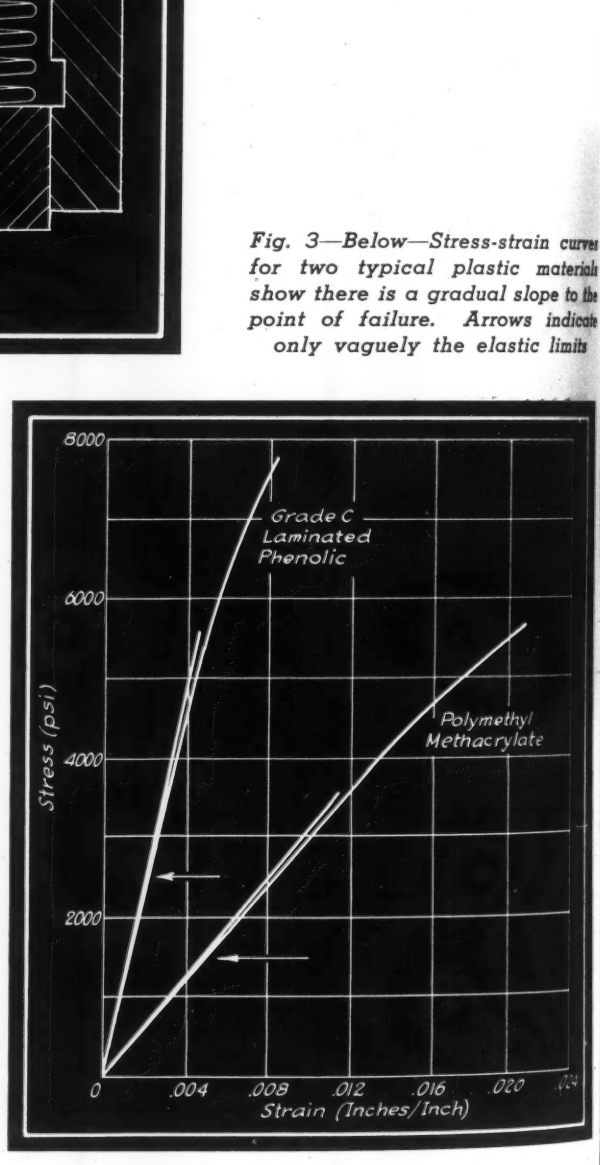


Fig. 3—Below—Stress-strain curves for two typical plastic materials show there is a gradual slope to the point of failure. Arrows indicate only vaguely the elastic limits

chine parts, such as the gears of *Fig.* 1, it will be necessary to consider temperature, humidity, and other influences.

Generally speaking, plastics in application to machine design problems have been stressed too high; in many instances this has been due to inaccurate interpretation of published physical properties of plastics. To illustrate the point, designers of metal components are accustomed to working with metals whose yield strengths may be 50 to 75 per cent of the ultimate breaking loads. In the case of plastics, the range may be more accurately located at 10 to 25 per cent of the ultimate breaking load for the majority of materials.

YIELD STRENGTH AND ELASTIC LIMIT: It is good engineering practice to stress materials at values safely below their elastic limit, and if there were reliable published figures on the elastic limit of plastic materials, there would not be any difficulty in suggesting working stresses. However, the available data on elastic limits of plastics is negligible, though there are some reliable results on the yield strength. In dealing with metals it would be safe to assume that the elastic limit was in close proximity to the yield strength. This is an erroneous assumption for plastics and, because of the wide discrepancy between yield strength and elastic limit, designers who have based their stress calculations upon yield strength values undoubtedly have overstressed their materials.

Let us examine the significance of yield strength of plastic materials and how it will affect the application of engineering data on plastics to machines. To understand the effects which occur under stress, it is possible to visualize the mechanical behavior of plastics by referring to the model shown in *Fig.* 2. The model is designed to ex-

TABLE I

Apparent Elastic Limits

Material	Apparent Elastic Limit (psi)
Molded Phenolic (rag filled)	2600
Molded Phenolic (wood flour filled)	1900
Polymethyl Methacrylate	800
Cellulose Acetate	400
Laminated Phenolic, Grade C	1400

TABLE II

Influence of Temperature on Physical Properties

(Relative Values)

Plastic	Tensile			Flexural			Impact			Modulus of Elasticity		
	Zero F	75 F	150 F	Zero F	75 F	150 F	Zero F	75 F	150 F	Zero F	75 F	150 F
Polystyrene	1.2	1	.71	1.1	1	.67	1	1	1	1.2	1	.74
Phenolic Molding Material, (general purpose)	1.07	1	.90	1.15	1	.83	1	1	1	...	1	...
Cellulose Acetate Molding Material and Cellulose Acetate Butyrate	1.6	1	.40	1.7	1	.48	.40	1	2.0	1.14	1	.70
Polymethyl Methacrylate	1.37	1	.30	1.43	1	.36	1	1	1	1.5	1	.25
Polyamide (Nylon)	1.5	1	.71	...	..	..	.67	1	12.7	...	..	..

plain three concomitant phenomena: Elastic deformation (instantaneous under stress); plastic deformation (dependent on time, temperature, and stress); and permanent set. Compression or elongation of the top spring represents the elastic phenomena (perhaps the straightening out of the molecules under stress, where the primary valence bonds are affected). Displacements between molecules involving straining of secondary valence forces can be represented by the deformation of the second spring, which occurs with the passage of time during the overcoming of friction between the middle disk and shell. As the load is released, however, the energy stored in the second spring contributes to the time-dependent recovery curve. The second friction disk at the bottom of the illustration indicates that if stresses are of sufficient magnitude or duration in time, even some of the energy stored in the second spring may be permanently relieved, contributing to the condition which is commonly known as permanent set.

After studying the model in *Fig.* 2 one should find it easier to visualize such conventional stress-strain curves as are shown in *Fig.* 3 for plastic materials, where a gradual slope to the point of failure is indicated. The two arrows in *Fig.* 3 *vaguely* point to the elastic limit. Thus, it becomes apparent why there is some reluctance to indicate values of the elastic limit of plastic materials, and hence, the working stresses. The problem is further complicated by observations of creep at low values of stress (2).

One further bit of experimental data which indicates the significance of the reported values of yield strength is the graph in *Fig.* 4 which depicts yield strength of a plastic material as a function of the rate of load application. This was replotted from data recently reported (3). Thus yield strength, which should be a specific property of the plastic material, is in fact a function of the method and rate of applying load.

By a newly developed technique, values of the elastic limit of plastic materials have been determined by the

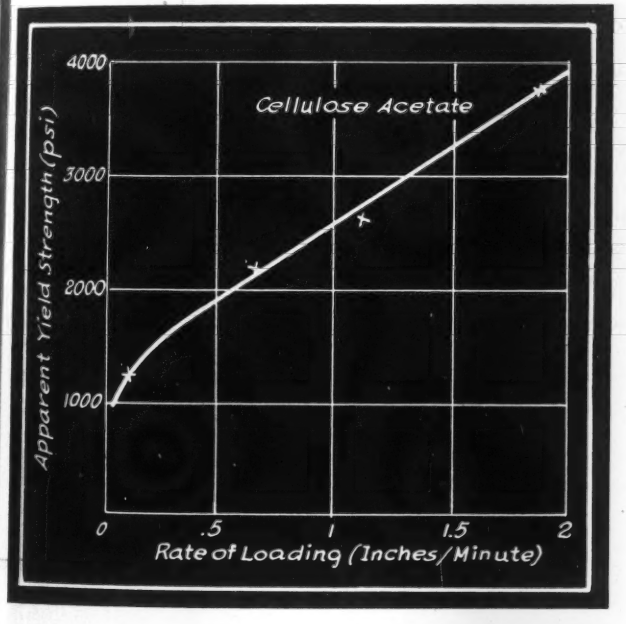


Fig. 4—Above—As this curve indicates, yield strength is not a specific property of a plastic material, but rather a function of the method and rate of load application

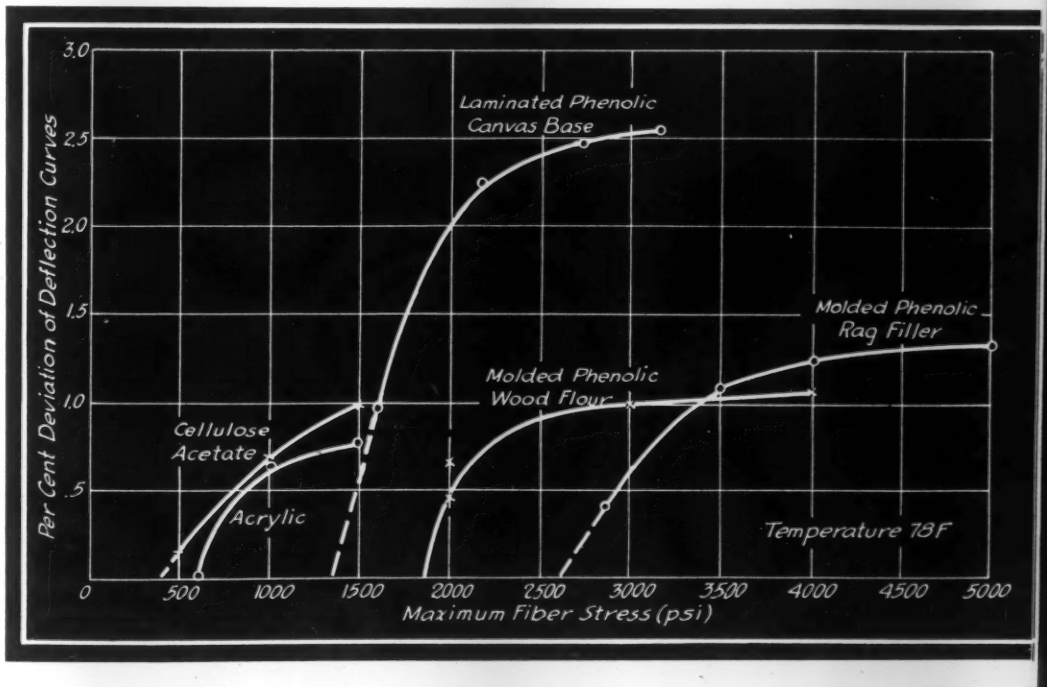


Fig. 5 — Right — Apparent elastic limits of plastics at room temperature were determined from interpretation of these curves

writer (4). These were obtained by a meticulous study of load-deformation curves in flexure for various time intervals and various fiber stresses. From examination of the hysteresis effects (denoted by percent deviation of deflection curves, *Fig.* 5), the apparent elastic limit is determined. These values have been proposed as the maximum values of working stresses for plastics at room temperature (75 to 80 degrees Fahr.). The values for representative compounds are shown in TABLE I.

TEMPERATURE EFFECTS: Working stresses of plastics are dependent upon the temperature at which the materials must operate as well as the previous temperature history of the plastic. Thermal expansion and contraction may lead to dimensional changes which affect the success of the application. The problem is particularly acute in the combination of metals and plastics where severe internal stresses may build up in the plastics during changing temperatures. There is not a great deal of latitude in changing the expansion coefficients of the materials, hence the design must make the necessary allowances to avoid developing excessive internal stresses. On the average, plastics expand two to six times as much as metals.

Plastic materials, it must be remembered, are thermal-responsive materials. They have been formulated to be molded or formed under heat and pressure. These same characteristics are retained, though to a lesser degree by thermosetting materials, in the finished product. In TABLE II the variation in physical properties of representative plastics at different temperatures is presented. From this chart may be estimated the factor of safety which should be allowed the working stresses for changes

Fig. 6—Below—Curves show influence of prolonged heating on flexural strength of some thermosetting plastics. In addition to these losses indicated, there is in all cases a decrease in impact strength. These effects may be due to loss of plasticizer and of residual moisture

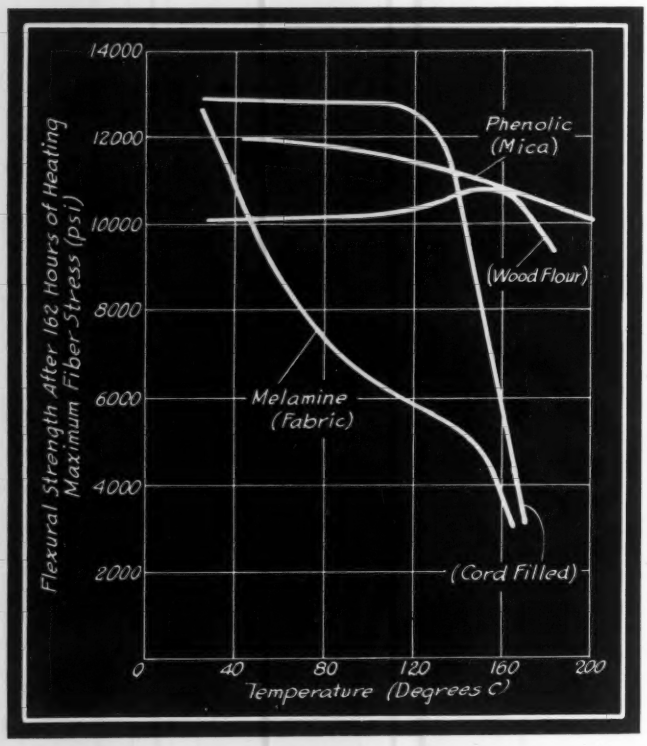
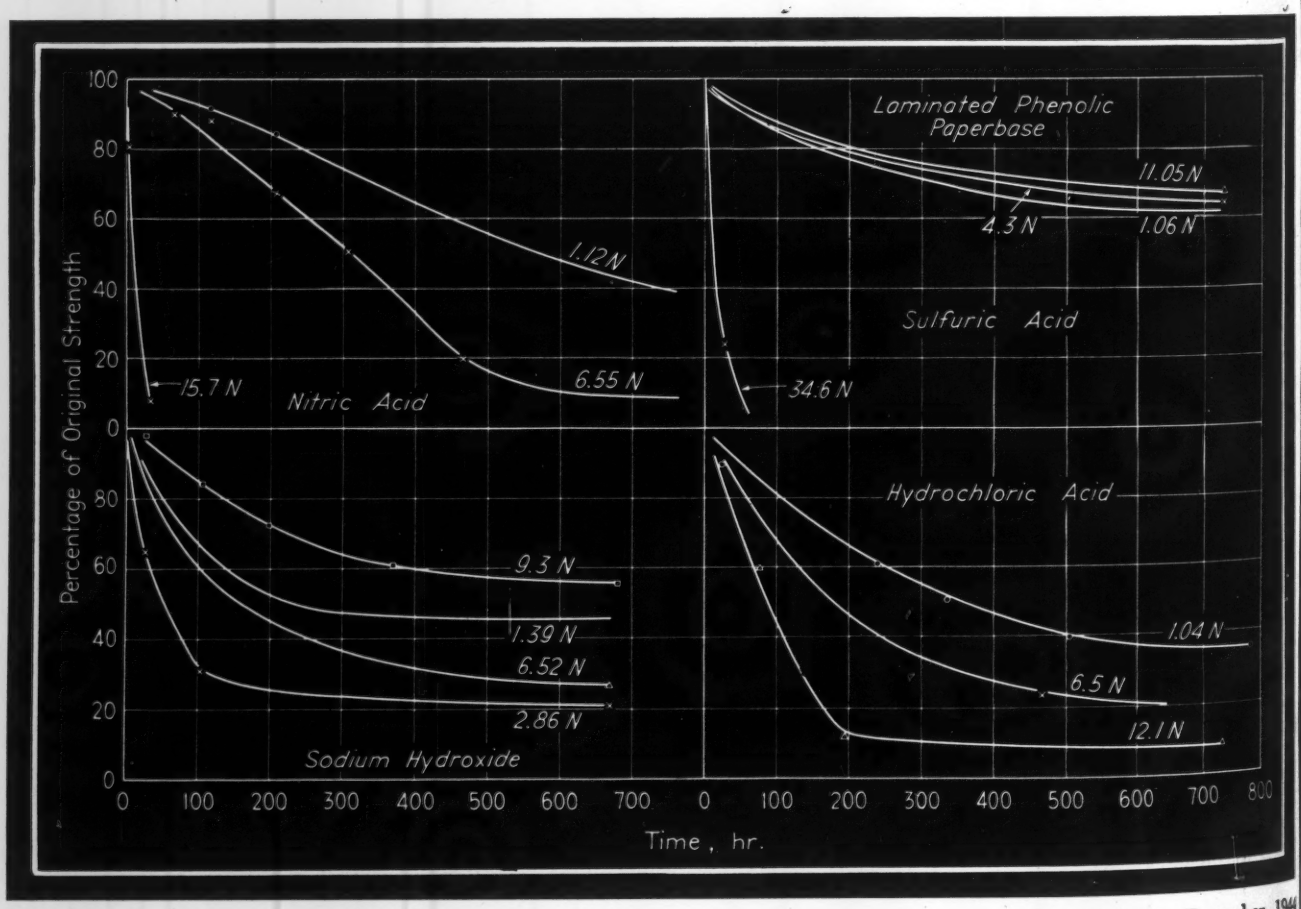


Fig. 7—Below—These curves show that paper-base phenolic laminate loses strength under action of the chemicals noted. Symbol N means "normal solution"



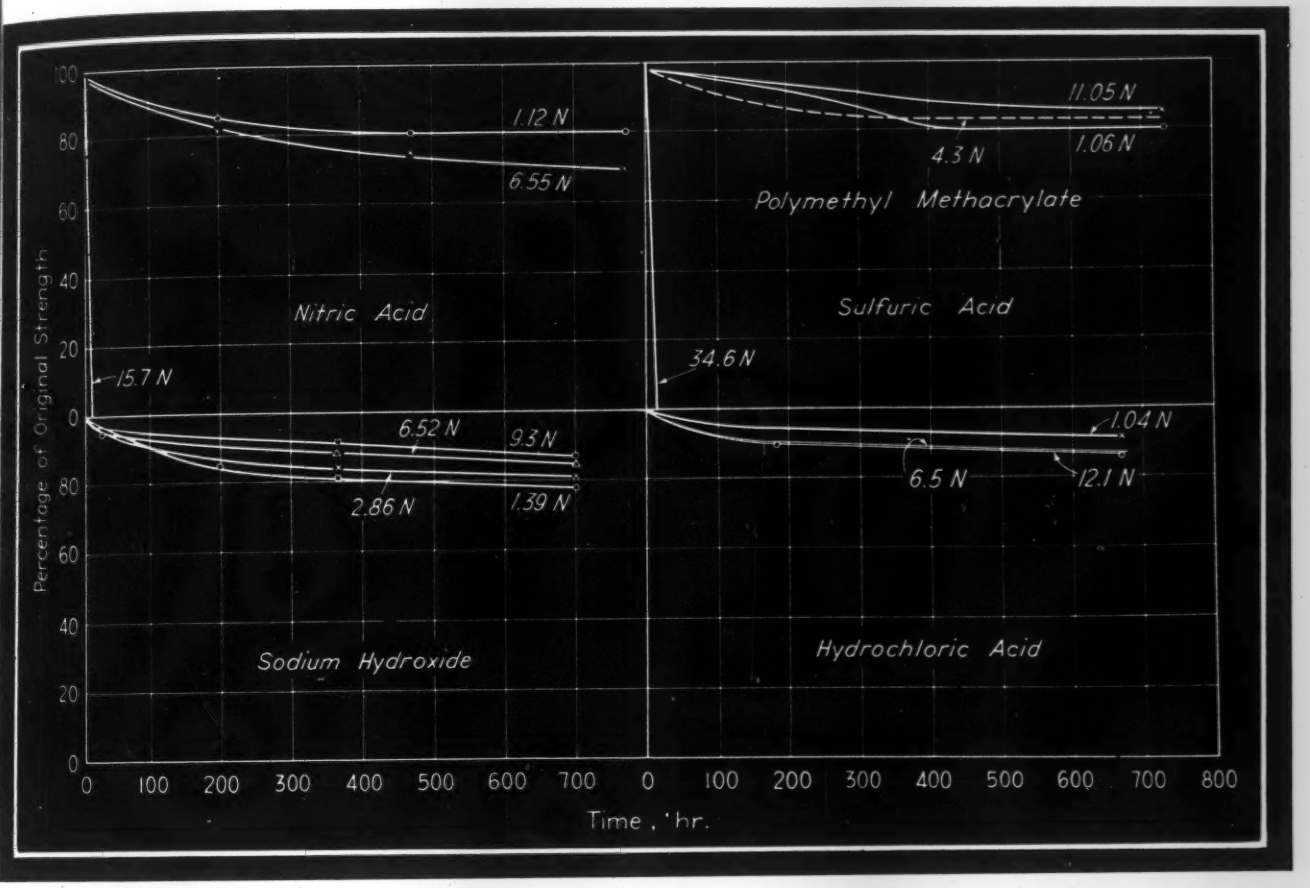


Fig. 8 — Effects of various chemicals on polymethyl methacrylate are not as severe as on phenolic laminate

in temperature. Among the materials absent from this table are urea and melamine-formaldehyde, for which comparative temperature data were not available to the writer.

Prolonged exposure to elevated temperatures may result in permanent changes in the properties of plastics due to one or more of the following factors:

1. Loss of plasticizer
2. Increase in degree of polymerization
3. Loss of residual moisture.

The most apparent change is in impact strength which is decreased in all cases, as measured on return to room temperature. For most phenolic plastics the changes incurred are negligible at long time exposures to temperatures at 200 degrees Fahr. or under. However, between 200 and 300 degrees Fahr. there is a marked difference in behavior, particularly for cellulosic-filled phenolic plastics, which lose strength quite rapidly at 300 degrees Fahr. and above. In an excellent study of the effects of temperature on various plastics, Carswell and Nason (5) have shown the data which appear in *Fig.* 6, demonstrating the influence of prolonged heating on the flexural strength of various thermosetting plastics. This same paper also discusses humidity and temperature effects.

Thermoplastic materials, on the other hand, are seldom employed at temperatures beyond their heat distortion points which average between 150 to 190 degrees Fahr. However, the new heat-resistant thermoplastic compounds of polydichlorostyrene, modified polystyrene, and others, will necessitate examination of the behavior on continued high temperature exposure.

HUMIDITY EFFECTS: The influence of moisture on physical properties depends on the plastic under investigation. Some of the plastics, such as polystyrene, polyethylene, and polyvinyl chloride-acetate, are scarcely affected at all. On the other hand, materials such as cellulose acetate may be altered quite markedly.

Swelling and shrinking during changes in humidity may be ascribed to absorption and evaporation of moisture by the plastic. These dimensional changes are not usually of serious consequence unless they occur in conjunction with materials which do not change under the same conditions. For example, a tight-fitting bearing of laminated phenolic may fail as it swells in contact with water and seizes against a steel shaft. The .6 or .7 per cent dimensional change may develop an excessively high internal stress even in a material whose modulus of elasticity is in the neighborhood of 1,000,000 pounds per square inch.

TABLE III

Bending Fatigue Strength

Material	Bending Fatigue Strength (psi)
Phenolic Plastic (cellulosic filler)	1950
Cellulose Acetate	1000
Polymethyl Methacrylate	2000
Laminated Cloth (phenolic)	4320

EFFECT OF FATIGUE: While technical literature on fatigue characteristics of plastics has been rather meager, there have been a few recent publications which add con-

siderably to the store of knowledge on the subject (6). With an average testing speed of 1500 to 1750 cycles per minute, the bending fatigue strength of most plastics lies between .2 to .3 of the mean static modulus of rupture after 20 million cycles of alternating stress. Representative values reported in this paper are given in TABLE III.

In comparing the data of TABLE III with the working stresses in TABLE I, it must be recognized that the former data are largely intended for unidirectional stresses under sustained loading, where plastic flow is amplified. Loading under alternating stresses is not influenced to the same extent.

EFFECT OF CHEMICALS: Some plastics, like polydichlorostyrene, polyethylene and polyvinylidene chloride, and to a slightly lesser extent polystyrene and polyvinyl chloride-acetate, possess outstanding resistance to various acids and alkalies. For most concentrations of sulphuric and hydrochloric acid, as well as sodium hydroxide, these plastics do not suffer in loss of working strength. On the other hand the effect upon some of the more common plastics may be much more pronounced. The behavior of laminated phenolic, polymethyl methacrylate and cellulose acetate under various concentrations of chemicals is shown in the curves of *Figs.* 7, 8 and 9 (7). The falling off in strength is quite marked in contact with the strong acids, all of which indicates still further corrections which may have to be made in utilizing plastics in machines having contact with various chemicals.

Chemical activity is considerably more vigorous at higher operating temperatures and the allowable stresses may be quite low. Where solvent vapors are present, the machine designer should refer to the plastic materials supplier for data on the many types of solvents.

EFFECT OF MANUFACTURING CONDITIONS: Not to be overlooked is the somewhat intangible factor of the manufacturing operation. The same molded part produced in two different molds may give entirely different results and reflect the skill and experience of the mold designer and mold operator. Due allowances must be made for manufacturing inconsistencies. The natural processes of injection, transfer, and compression molding produce pieces which are far from strain free. Since plastic parts are molded under tremendous pressures, internal strains are to be expected.

It will be seen from the foregoing that many factors influence the determination of allowable working stresses for plastics. As in all other phases of engineering, much research remains to be done before the true nature of all of these factors can be ascertained and completely correlated.

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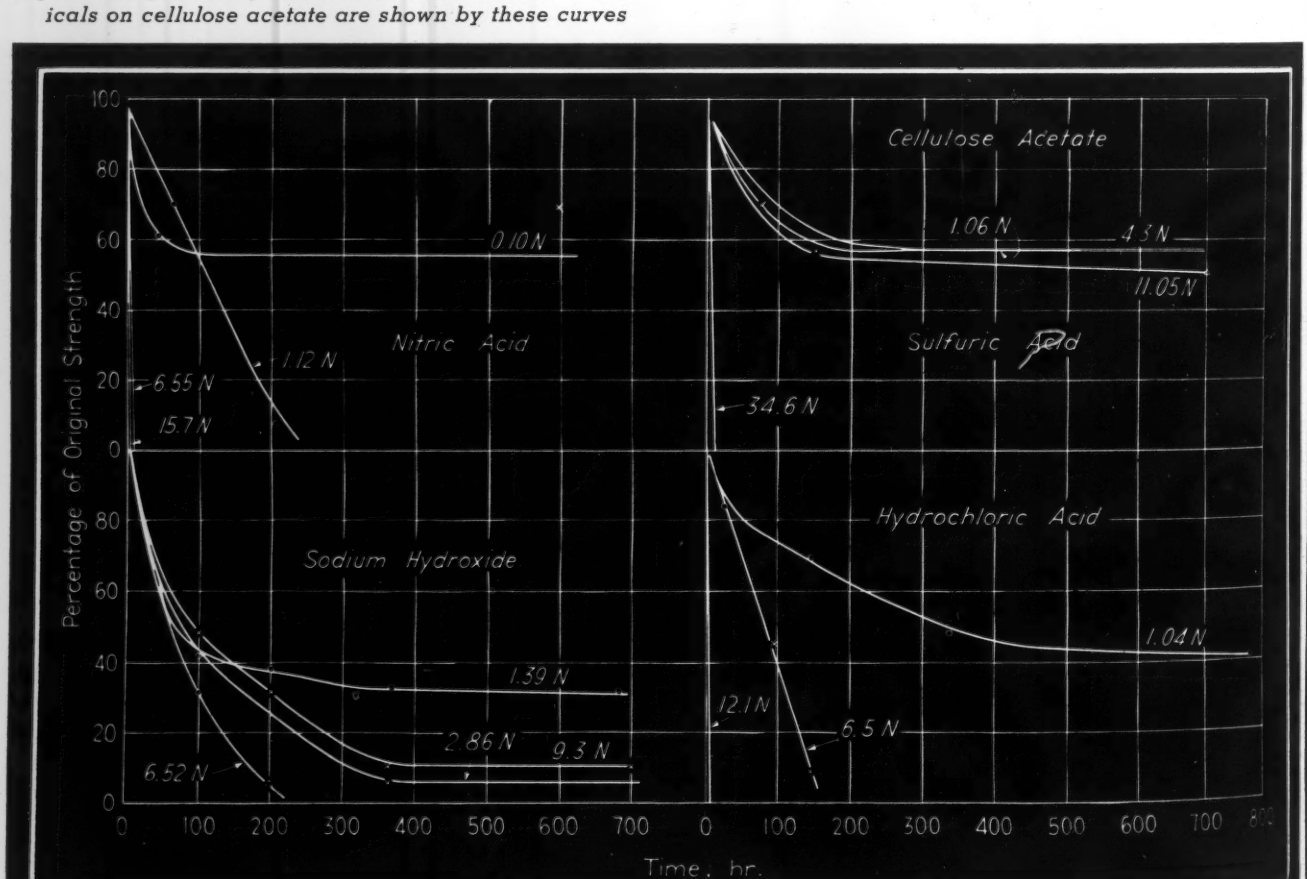
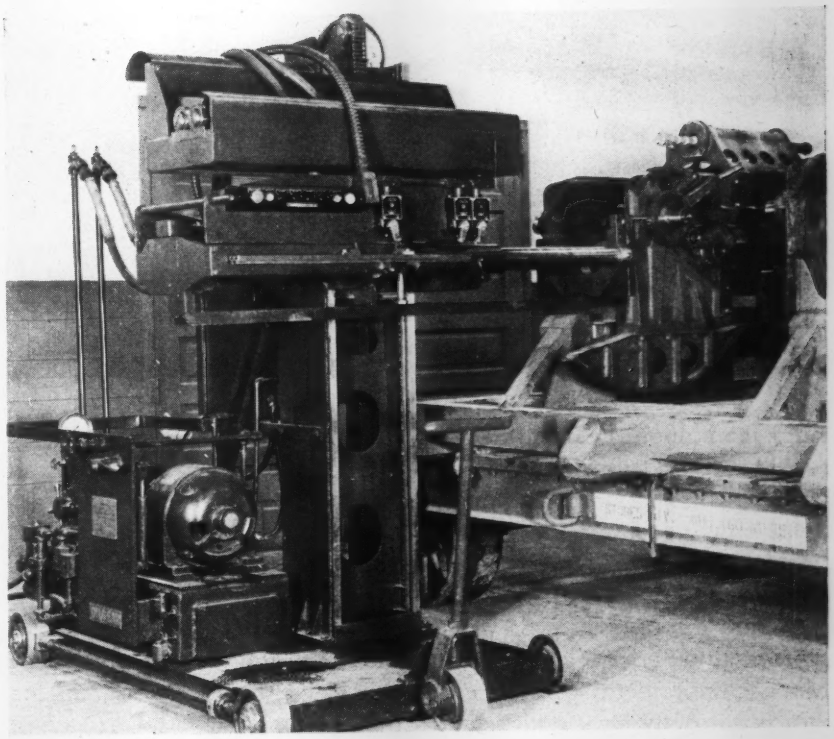
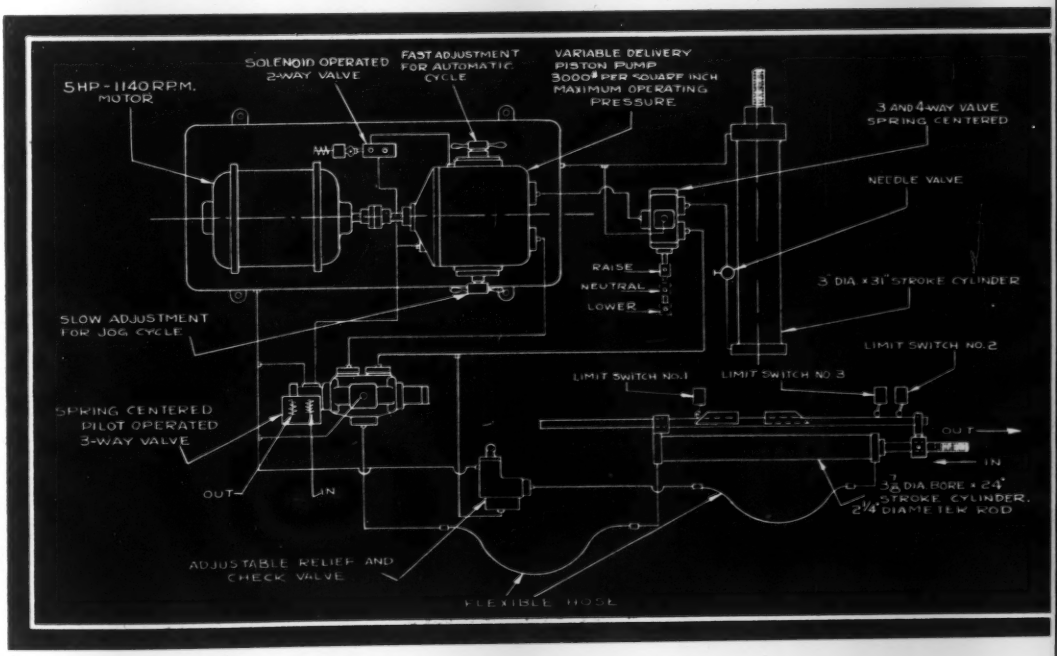


Fig. 9—Comparatively severe deleterious effects of chemicals on cellulose acetate are shown by these curves

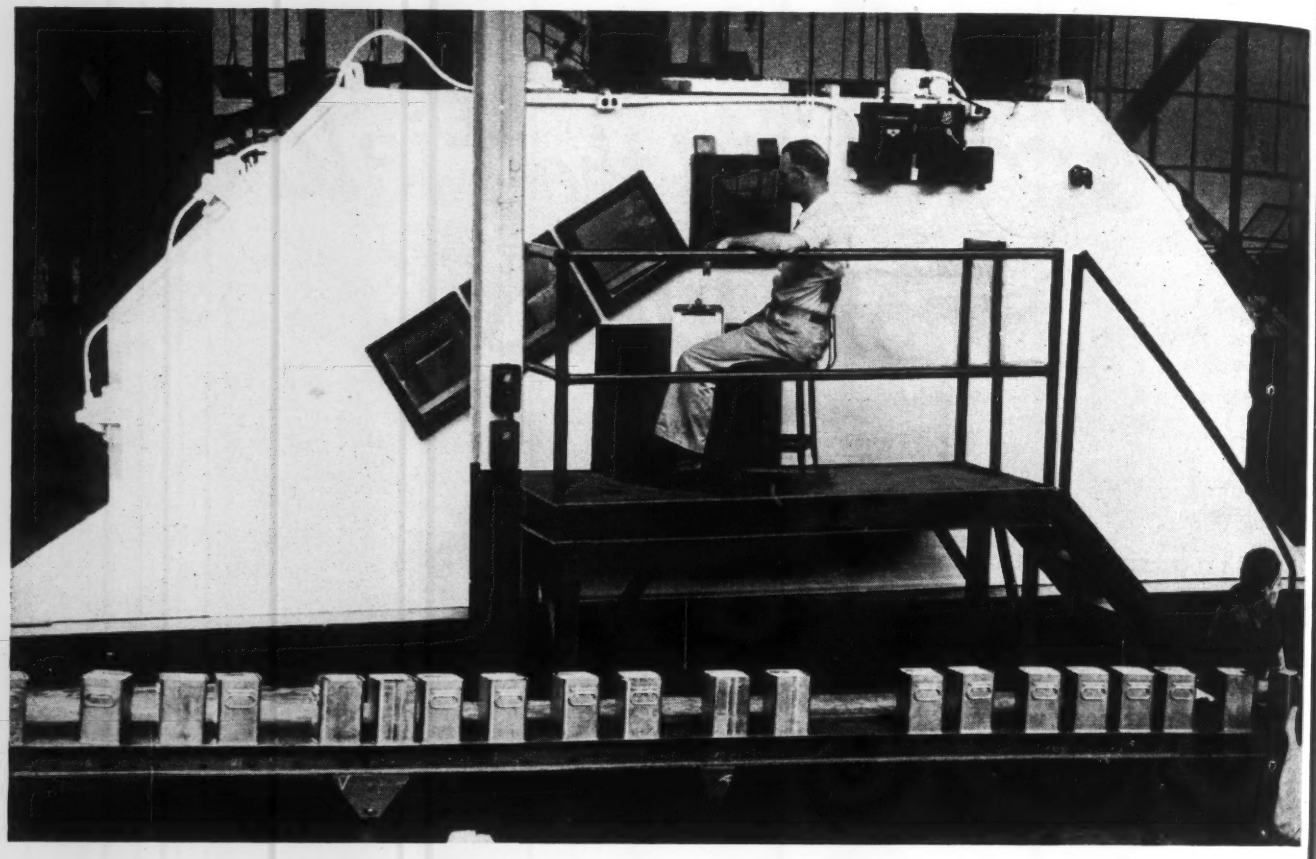
Scanning the Field for Ideas

Testing and exercising gun recoil mechanisms requires a machine having ample power for drawing out the recoil rods, yet compact enough for ease in handling. To achieve this combination the Jackson Hydraulic Machine Co. Inc. developed the portable machine at right for exercising recoil assemblies of antiaircraft guns. Hydraulic drive was selected because of the great amount of power that can be centered in a small space. The pumping unit operates on a maximum pressure of 3000 pounds per square inch and will exert a pulling force on the gun mechanism of 23,450 pounds. The hydraulic circuit, shown at right, has electric control because of its flexibility, with automatic cycling where a given length of stroke is required. The machine can be operated also on a longer stroke when the cycle stop button is depressed. Cycling is automatically controlled by limit switches. Speed of piston travel is adjustable both for the jogging and automatic circuits. Elevation of the unit to the height of a gun recoil is pushbutton-controlled.





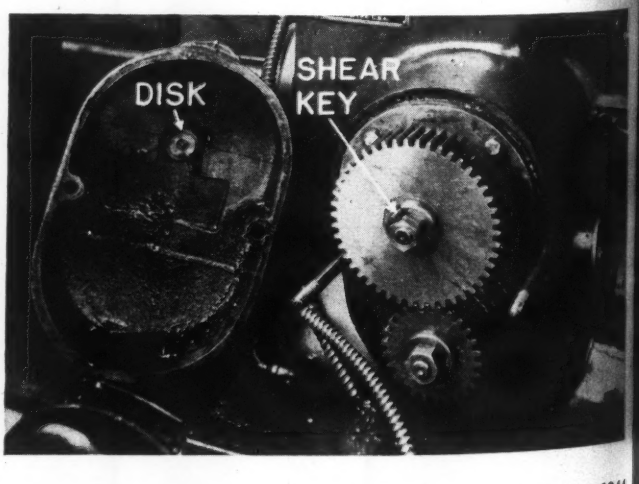
Vacuum - testing to detect leaks in hermetically sealed metal car-



tridge containers is facilitated by the test chamber illustrated above. Devised by the Chrysler Corp., the machine is capable of testing 780 metal cans per hour for .45 and .30-caliber carbine cartridges. The containers enter the machine at the left on a conveyor in such a way that they pass through a lower water tank and travel upward into the vacuum area. If a metal container is imperfect it will allow bubbles to be discharged rapidly as it enters the test chamber because of the greater pressure within the can.

The machine is of relatively simple design. A float-control valve maintains a predetermined level in the lower water tank and a constant volume of liquid in the entire system. An automatic vacuum float-valve control disconnects the vacuum pump system when the proper head of water and vacuum is reached in the upper test chamber. A small gearhead motor keeps the conveyor in motion and an overload type of clutch acts as a safety device on the conveying of the product. Water in the lower tank is automatically sealed from the upper test chamber at the positions where the cans enter and leave the top section of the machine. A projected method for rejecting imperfect cans automatically involves a photoelectric tube circuit which would pick up the action of the bubbles, disturb a beam of light and actuate a solenoid pusher arm to shove the faulty can onto a second conveyor for handling rejects.

Interlocking machine control with a shear pin protects an automatic machine from completing its cycle should the machine jam. Utilizing an electric limit switch in conjunction with the shear pin as shown in the illustration below has considerably reduced cutter breakage on a special plunge milling operation at General Electric's Erie works. The shear key used is brass, the length and strength of which was determined by experimentation so that the key would fail before the cutter became damaged. When the key shears, the projecting end which rides against a disk connected to the limit switch falls free. This action releases the switch, breaking the control circuit and causing the machine to stop as though the cycle were completed.



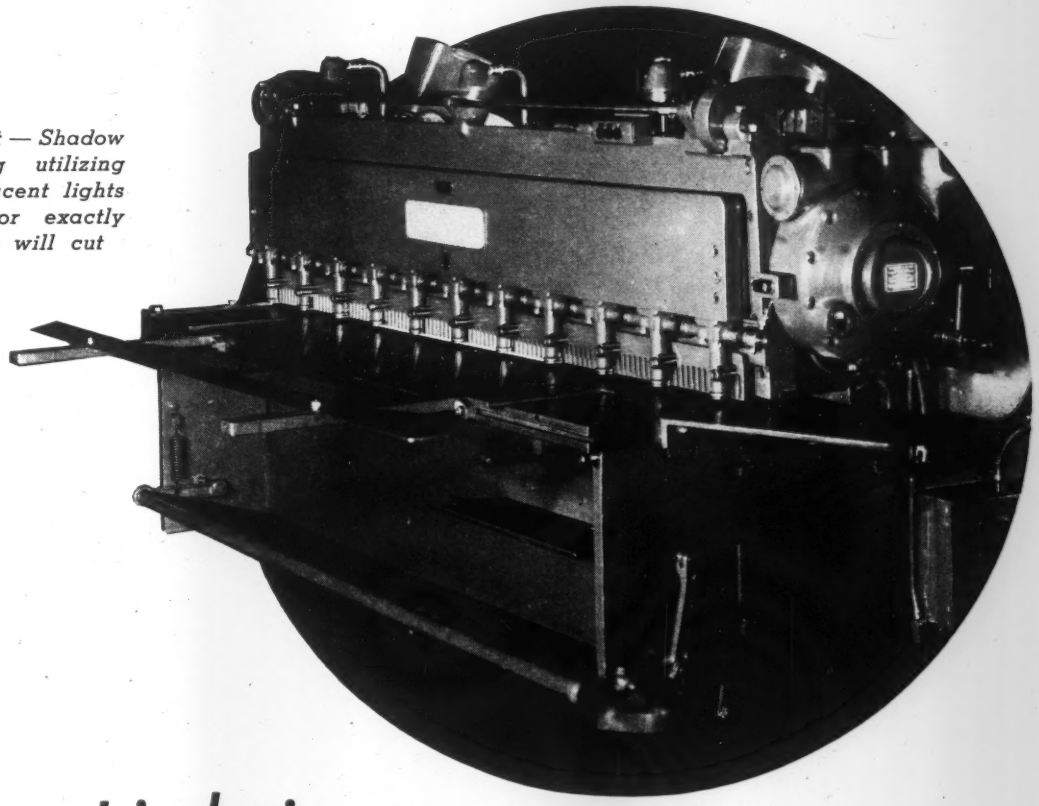
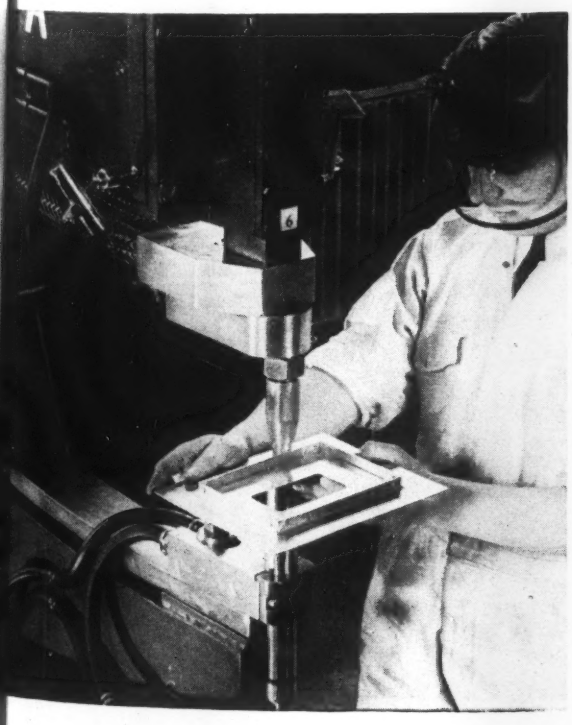


Fig. 1 — Right — Shadow gage lighting utilizing built-in fluorescent lights shows operator exactly where shear will cut

Machine Lighting Increases Operator Efficiency



By John W. Greve

AMONG the refinements that will be incorporated in new machines, lighting necessarily will receive considerably more attention than in the past. Although machine speeds and precision may not increase markedly, the trend toward designing machines as complete units in every detail coupled with the need for reducing operator fatigue to the minimum indicate that machine lighting will be tailored and incorporated as an original part for each machine unit involving "seeing tasks".

Even as the placing of controls within easy reach of the operator is recognized as essential for reducing operator fatigue

Fig. 2—Left—Two focused spotlights indicate where machine will weld as well as the spacing between welds

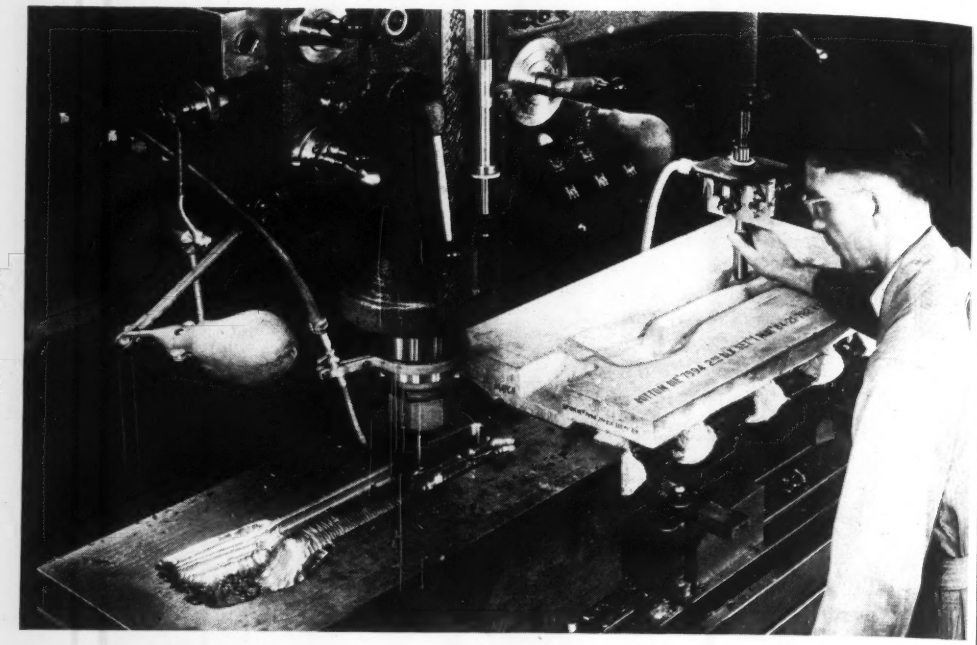


Fig. 3—Right—Adjustable lights aid operator in watching cutter and details of master

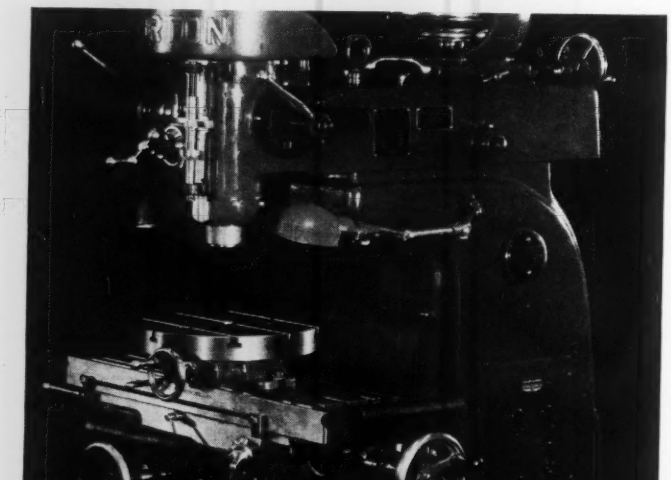


Fig. 4—Above—Dual lights reduce objectionable shadows and also reduce the necessity for frequently adjusting the light

as well as unit production costs, adequate lighting is becoming more and more a necessity. Many operator tasks are limited by the ease with which the eye recognizes details of work in process, machine settings, etc. As seeing is facilitated, just so much are certain operations speeded up and set-up time, spoilage and accidents reduced.

Proper illumination requires coordination of machine lights with general illumination. Because machines are seldom designed for a specific set of conditions where all the factors of general illumination are known in advance, it is usual to design the machine lighting for average conditions, favoring a surplus of light rather than taking a chance on insufficient illumination.

Local lighting for areas requiring close operator observations should provide brightnesses of 2 to 3 times that provided in the surroundings by general illumination considered adequate for the type of work being performed. The actual illumination to give such brightness

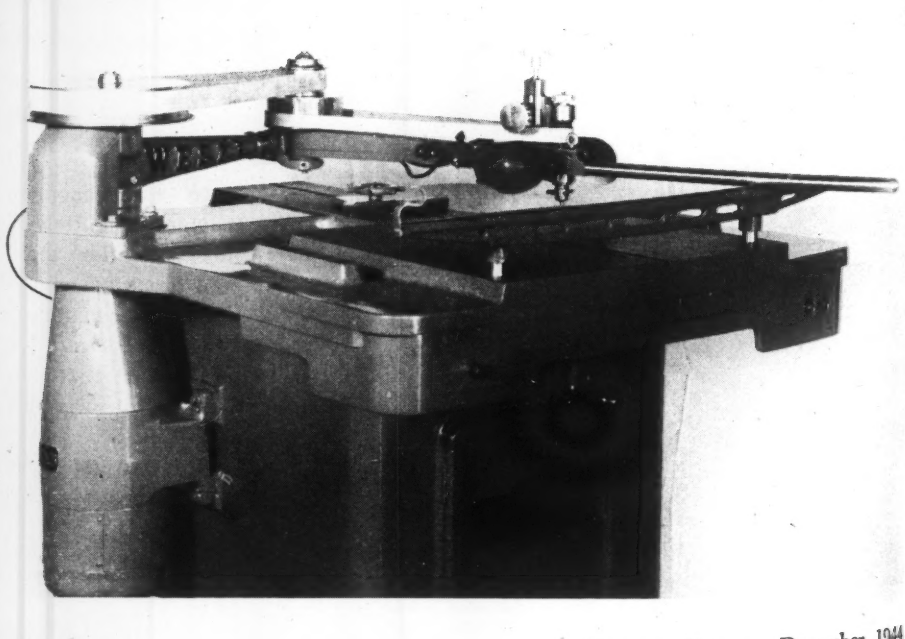


Fig. 5—Right—Close-coupled lights on each side of router arm follow tool motion to give maximum light on work

is a factor of the reflection values of the work and surroundings, since brightness is a direct function of both illumination and surface reflectance. Critical seeing tasks in addition to observation of the work itself include reading of dials, instruments and control settings. Occasional checking of other machine functions usually can be accomplished with the aid of the general lighting in the room.

Quality Is as Important as Quantity

Quality of lighting is equally as important as the quantity of light. Light sources should always be so placed that the working areas will be evenly illuminated without specular reflections to annoy the operator or stray light rays to interfere with operators of other machines. Filament or fluorescent lamps in well-designed reflectors, protected by cover glasses to simplify maintenance and advantageously located, usually can be applied to provide proper light for the necessary seeing tasks. Bare lamps should seldom, if ever, be used for actual illumination. They may, however, be used as low candlepower indicators to good advantage.

Visibility does not depend upon the quantity of light alone. Good contrast between a workpiece and its background, between a figure on a dial and its background, etc., contributes greatly to the ease with which seeing tasks are performed. For this reason work areas are more frequently being painted with colors carefully selected for the purpose. Light colors are also used to help direct light rays into dark corners, etc. Specular reflections contribute to eye fatigue and for that reason satin finishes for micrometer dials are gaining favor.

Distribution of reflected images on a metallic surface is a function of the area of the light source and its distance from the work. This important consideration is discussed by A. K. Gaetjens (M.D., March 1941, Pages 40-43). Charts are presented for the usual work conditions where both plane surface and convex surfaces are to be lighted. The data are developed for specular surfaces; other surfaces would have somewhat larger reflected images depending upon the degree of departure from a specular surface. The charts are useful in obtaining an idea of the results that are desired.

Illumination Recommended for Specific Tasks

To insure that a given illumination will be maintained even where conditions are favorable it is necessary to design the system to give initially at least 25 per cent more light than the required minimum, according to the American Standards Association's "Recommended Practice of Industrial Lighting". In locations where dirt will collect rapidly and where adequate maintenance is not provided, the initial value should be at least 50 per cent above the minimum requirement. The following tabulation gives a general idea as to the illumination recommended by A.S.A. for seeing fine detail:

GROUP A: These seeing tasks involve the discrimination of extremely fine detail under conditions of extremely poor contrast, for long periods of time. To meet these requirements, illumination levels above 100 footcandles are recommended.

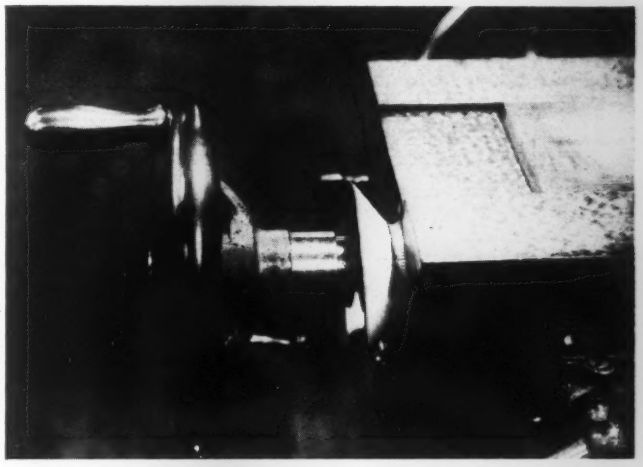
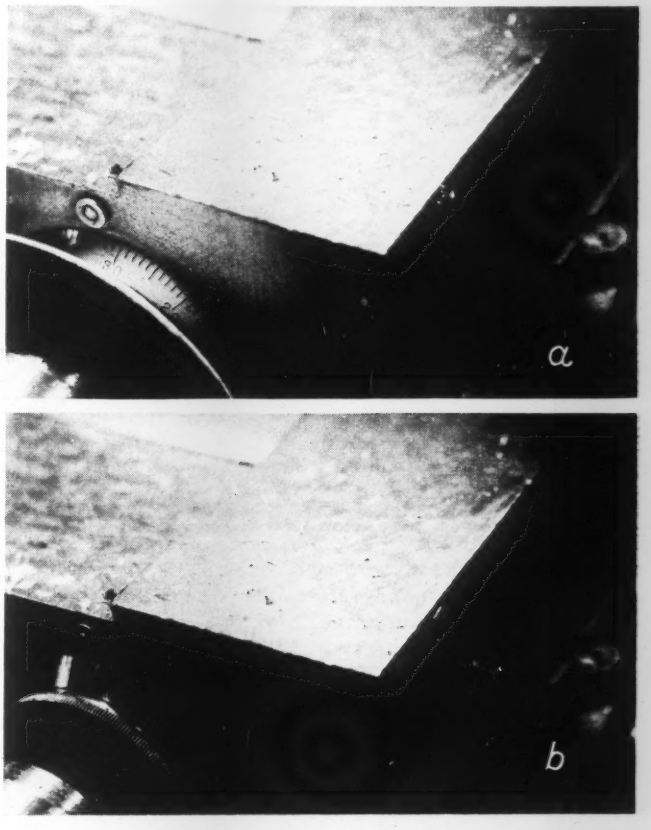


Fig. 6—Above—Cone collar on micrometer dial reflects light, making it easier to read

Fig. 7—Below—At (a) is shown improved readability of dial in Fig. 6 compared to dial without collar at (b), otherwise under the same lighting conditions



To provide illumination of this order a combination of at least 20 footcandles of general lighting plus specialized supplementary lighting is necessary. The design and installation of the combination systems must not only provide a sufficient amount of light but also must provide the proper direction of light, diffusion, eye protection, and insofar as possible must eliminate direct and reflected glare as well as objectionable shadows.

GROUP B: This group of visual tasks involves the discrimination of fine detail under conditions of a fair degree of contrast for long periods of time. Illumination

levels from 50 to 100 footcandles are required.

To provide illumination of this order a combination of at least 20 footcandles of general lighting plus specialized supplementary lighting is necessary. The design and installation of the combination systems must not only provide the proper direction of light diffusion and eye protection, but insofar as possible must eliminate direct and reflected glare as well as objectionable shadows.

GROUP C: The seeing tasks of this group require the discrimination of fine detail by utilizing the reflected image of a luminous area or the transmitted light from a luminous area.

The essential requirements are that the luminous area shall be large enough to cover the surface which is being inspected and that the brightness be within the limits

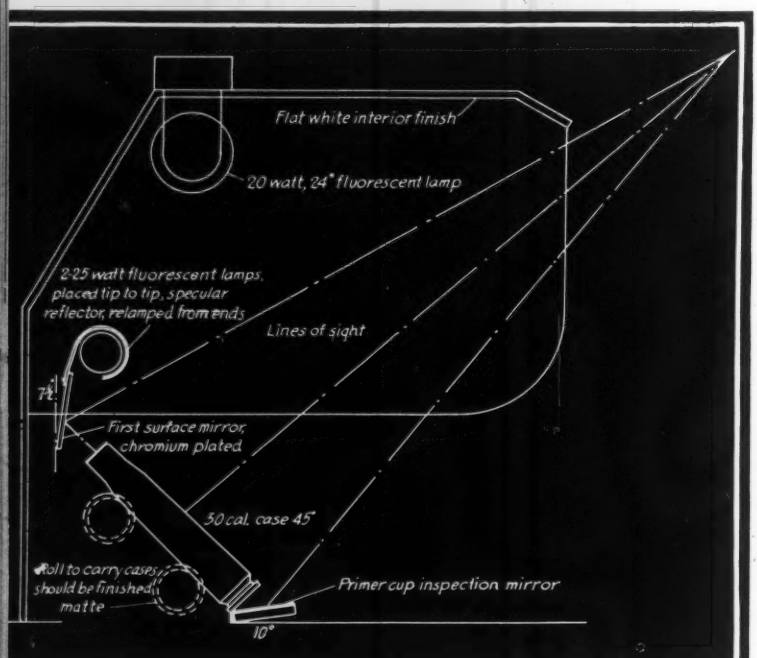


Fig. 8—Lighting hood designed for inspection of inside, outside and bottom of cartridge cases. Design precludes possibility of specular reflections annoying operator. Adjusted mirrors and proper lighting allow inspection of the three views at the same time

necessary to obtain comfortable contrast conditions. This involves the use of sources of large area and relatively low brightness in which the source brightness is the principal factor rather than the footcandles produced at a given point.

Even though modern general lighting in a plant provides levels of illumination above 50 foot candles on a 3-foot horizontal work plane, localized lighting units on individual machines are necessary because general lighting will not maintain this value on vertical surfaces and in recesses in adjacent areas. Neither will it maintain its level when materials creating shadows are introduced into the critical work area or when shadows are created by the operator.

Because micrometer dials on feeds are usually vertical they often are difficult to illuminate properly. An expedient which has proved useful is illustrated in *Fig.* 6. A small reflecting surface on a collar having a 45-degree angle throws light on the scale as shown in *Fig.* 7*a*. The same dial without the collar but otherwise under the same lighting conditions is shown in *Fig.* 7*b*.

Mirrors Aid Inspection

An interesting application of lighting involved the inspection of cartridge cases. Difficulty was experienced in lighting the inside of the case as well as the outside. Specular reflections would flash in the inspector's eyes and cause considerable fatigue. The lighting arrangement was redesigned as illustrated in *Fig.* 8. Cartridges are fed at a 45-degree angle through the hood by two rolls as shown. General illumination is furnished by a 24-inch, 20-watt fluorescent lamp placed directly above the cases so that specular reflections would not reach the inspector's eyes. To diffuse the light, the inside of the top of the hood is painted flat white. The primer cup at the bottom of the case is inspected by a mirror at 10 degrees. Two 25-watt lamps with a reflector and mirror light the inside of the case as shown. This mirror is a first-surface mirror in order that no secondary image would interfere with inspection. It is 11½ by 1½ inches, chromium plated, and is buffed vertically to reflect the images accurately. The lower edge is milled after buffing to insure optical flatness.

Many filament-lamp applications now in use will give way to fluorescent lighting where large-area light source and reduction of heat would be advantages. For instance in routers, small fluorescent lamps with reflectors and cover glass may be mounted on the tool arm sides in such a way as to take less room than filament lamps and give better diffused light over larger areas.

Circular Lamps Will Facilitate Design

Fluorescent lamps, after the war, will be available in standard circular shapes in addition to the straight lengths now in use. Approximately 20, 30 and 40-watt sizes will measure 8½, 12¼ and 16 inches in diameter. The 20-watt lamp with reflector and cover glass will give ample intensity at one foot for precision seeing. A lamp of this shape would be ideal on the spindle of a small precision drill press or similar machine. The lamp, surrounding the spindle, would always be close to the critical seeing area and would flood that area from all angles, obviating shadows.

So far only the surface has been scratched for built-in lighting applications. Because designers are becoming increasingly conscious of operator convenience, there are bound to be fast strides in this relatively new field of design.

Cooperation of the following companies in the preparation of this article is greatly appreciated: Benjamin Electric Mfg. Co., Des Plaines, Ill.; Cincinnati Shaper Co., Cincinnati, *Fig.* 1; Detroit Industrial Products Co., Detroit; The Fostoria Pressed Steel Corp., Fostoria, O., *Fig.* 5; General Electric Co., Cleveland, *Figs.* 6, 7, 8; George Gorton Machine Co., Racine, Wis., *Figs.* 3, 4; Illuminating Engineering Society, New York; Reliance Devices Co. Inc., New York; Sciaky Bros., Chicago, *Fig.* 2; Vimco Mfg. Co. Inc., Buffalo; Westinghouse Electric & Mfg. Co., Cleveland.

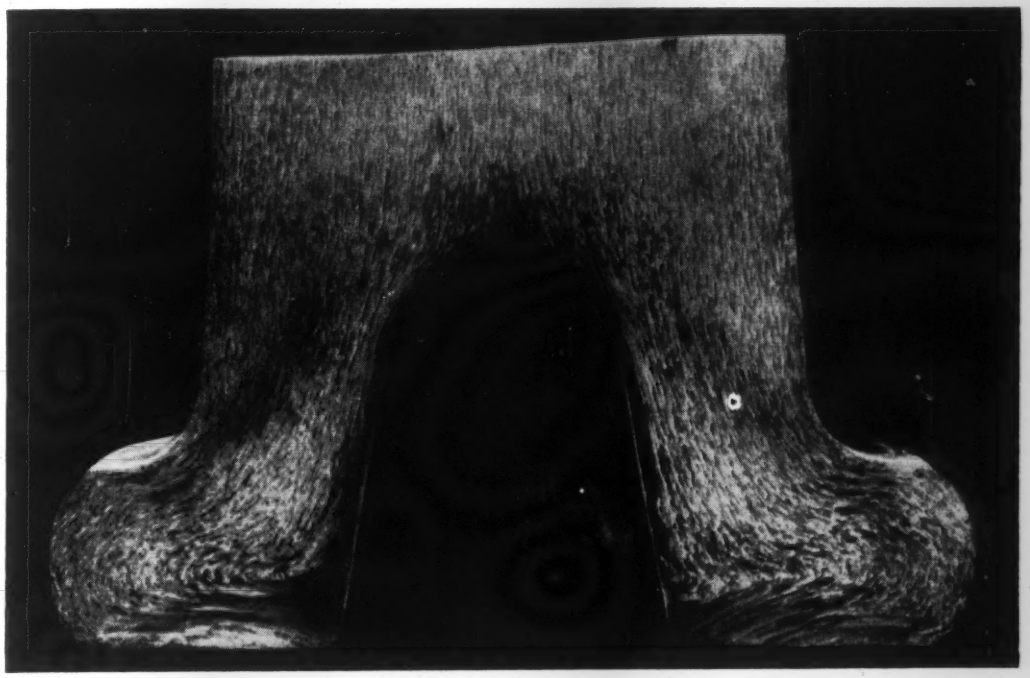


Fig. 1 — Macroetched cross section of the hub portion of a variable-pitch propeller forging of 25S-T alloy, showing flow lines

Designing Aluminum Alloy Forgings

By L. W. Davis
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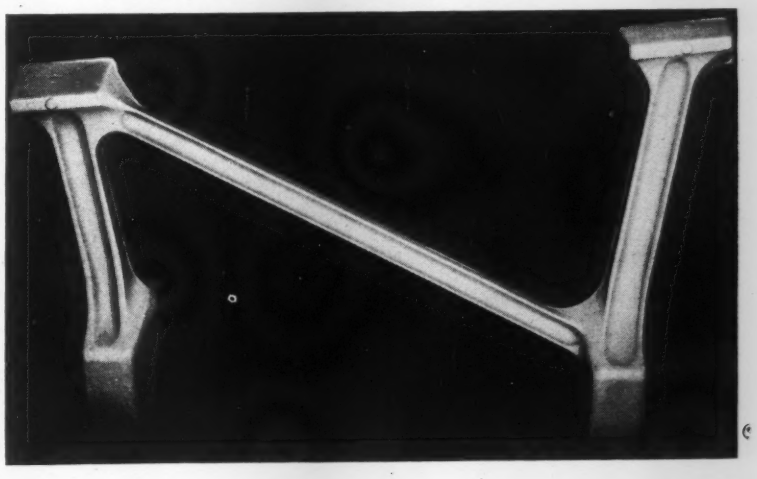
Cleveland

FOR several years the use of aluminum forgings, particularly in aircraft, has been undergoing rapid expansion. The productive capacity of the country today is at least 70 times that existing five years ago. Probably about 12 to 13 per cent of the metal produced in the country today eventually reaches the trade in the form of forgings. Depending upon the size and type of airplane, aluminum forgings represent from 10 to 18 per cent of the finished aluminum weight present in our military aircraft. This tremendous expansion has speeded up the normal process of evolution both in the development of forging materials and in the development of equipment for the production of forgings. Little information regarding these developments has found its way into technical literature, and therefore these facilities have not always been employed as advantageously as possible.

In discussing aluminum alloy forgings, no attempt will be made to go into detail concerning production methods. With the development of the art, the intricacy of the parts produced has increased materially. Although many things have been, and still can be, accomplished in this respect, there are certain limitations which should be appreciated. Some of these limitations as well as the possibilities of this type of product will be discussed.

In TABLE I the commercial wrought alloys of aluminum that are used today in production forgings are shown with their nominal chemical composition. Reference to TABLE II will indicate the mechanical properties obtained from these alloys. In the aluminum-copper series of alloys, 14S-T possesses the highest ultimate strength and also develops a considerably greater brinell hardness than any of the other materials. The use of this alloy has expanded more rapidly during the war than any of the other older materials because of the high mechanical properties, which

Fig. 2—Below—Large airframe structural fitting of unusual design in which flow lines were required to follow all three legs



Abstract of a paper presented at the recent annual convention of the American Society for Metals, in Cleveland.

Certain of the alloy compositions and forging practices described in this article are covered by United States patents owned by Aluminum Company of America.

Fig. 3—Preliminary blocking dies for part shown in Fig. 2. They produce a piece with the three legs parallel

have made it a highly suitable alloy for aircraft structural purposes. The use of 17S-T has not increased at the same pace as the other alloys for several reasons. Where high strengths are desired, 14S-T is used instead of 17S-T. It will also be noted that 25S-T has the same mechanical properties as 17S-T. This alloy is more easily worked at forging temperatures and does not age at room temperature as does 17S-T, thereby making it a more desirable forging alloy. The advantages left with 17S-T are better machinability and somewhat better resistance to corrosion. Recent tests have indicated that 14S-W with mechanical properties the same as 17S-T, is at least equivalent to 17S-T in resistance to corrosion. Therefore it is possible that in the near future 14S-W will be permitted as an alternate material. This means that 17S-T will disappear from the active list of forging materials. 11S which is the alloy that contains the lead and bismuth additions, has had limited forging application, since it is used only for those applications where its superior machinability makes it the most desirable material.

25S-T Widely Used Forging Alloy

As mentioned, 25S-T is desirable because it does not age harden at room temperature. This means that forgings can be straightened in the quenched condition (heat treated, but not aged) with little difficulty. This is the alloy employed today for most propeller blade forgings as well as for many smaller applications.

18S-T and 32S-T are used for forged parts in which the retention of strength at elevated temperature is essential. Pistons and air-cooled cylinder heads for aircraft engines are the principal products for which these alloys are employed, although there are other applications. Alloy 32S also has the advantage of a lower coefficient of thermal expansion than any other wrought aluminum alloy.

Where low cost is a primary consideration, alloys A51S and 70S are usually used. Both of these alloys can be forged much more readily than 25S, making for lower production cost. Because of this excellent forgeability large and intricate parts, such as radial aircraft engine crankcases, are made from A51S-T while they would be difficult and much more costly to produce in some of the harder alloys.

In order that dies may produce the number of pieces that they should, the most careful attention must be paid to die design and correspondingly to forging design. In any discussion of design one of the first points to be considered is the establishment of the proper grain flow lines in the part. All forgings are possessed of a characteristic structure imparted to them by operations incident to the production of the original forging stock such as rolling, extrusion or casting, as well as by the subsequent forging operations themselves. By the proper selection of stock and sequence of operations, this structure can be controlled and developed to conform to the

Table I
Nominal Composition of Aluminum Forging Alloys

	Percentage of Alloying Elements. Remainder Aluminum and Normal Impurities								
Alloy	Copper	Silicon	Manganese	Magnesium	Zinc	Nickel	Chrom.	Lead	Bismuth
11S	5.5	...	...	...	...	...	...	.5	.5
14S	4.4	.8	.8	.4	...	...	...	...	...
17S	4.0	...	.5	.5	...	...	...	...	...
18S	4.0	..	...	.5	...	2.0	...	...	...
25S	4.5	.8	.8	...	...	..	...	...	...
32S	.9	12.5	...	1.0	...	.9	...	...	...
A51S	...	1.0	...	.6	...	...	.25	...	...
53S	..	.7	...	1.3	...	...	.25	...	...
70S	1.0	...	.7	.4	10.0	...	...	...	...

Heat Treatment symbols have been omitted since composition does not vary for different heat treatment practices.

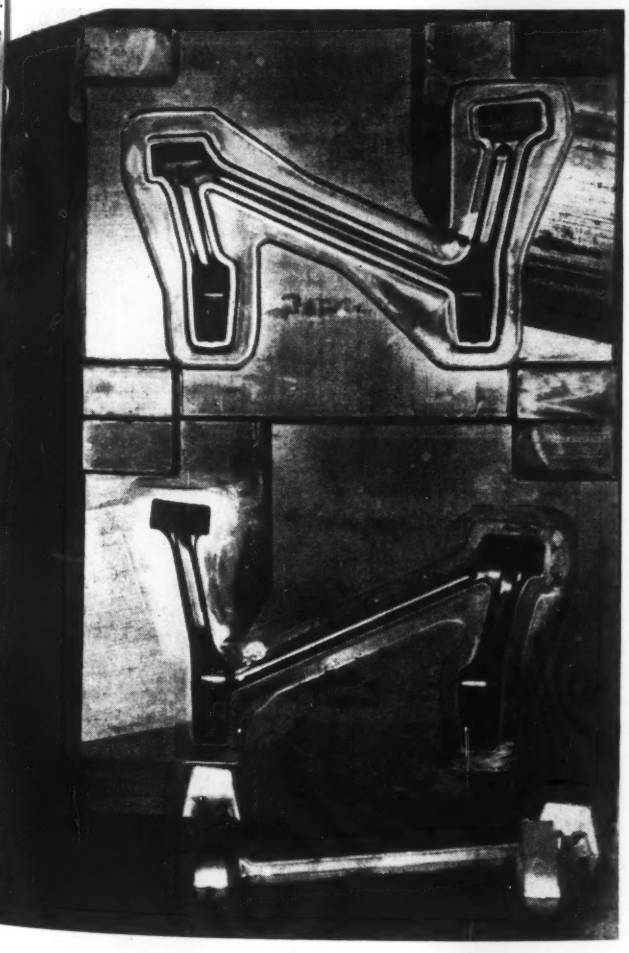
Table II
Mechanical Properties of Aluminum Alloy Forgings

	Minimum Specification Values — Tension			Typical Values (Not Guaranteed)			
Alloy	Yield Strength* (psi)	Ultimate Strength (psi)	Elongation (% in 2-in.)	Hardness Brinell (500 Kg., 10-mm. Ball)	Shear Strength (psi)	Fatigue Endurance Limit (psi)	Density (Lb. per cu in.)
11S-T	34,000	55,000	12	90	31,000	13,000	.101
14S-W	30,000	55,000	16	100	36,000	15,000	.101
14S-T	55,000	65,000	10	130	45,000	16,000	.101
17S-T	30,000	55,000	16	100	36,000	15,000	.101
18S-T	35,000	55,000	10	100	38,000	14,500	.103
25S-T	30,000	55,000	16	100	35,000	15,000	.101
32S-T	40,000	52,000	5	115	38,000	14,000	.097
A51S-T	34,000	44,000	14	90	32,000	10,500	.097
53S-T	30,000	36,000	16	75	24,000	11,000	.097
70S-T	40,000	50,000	16	85	37,000	19,000	.107

*Set=.2 per cent.

Fig. 4—Above—Blocking dies for part shown in Fig. 2. Legs are still parallel to flow lines in bar stock used

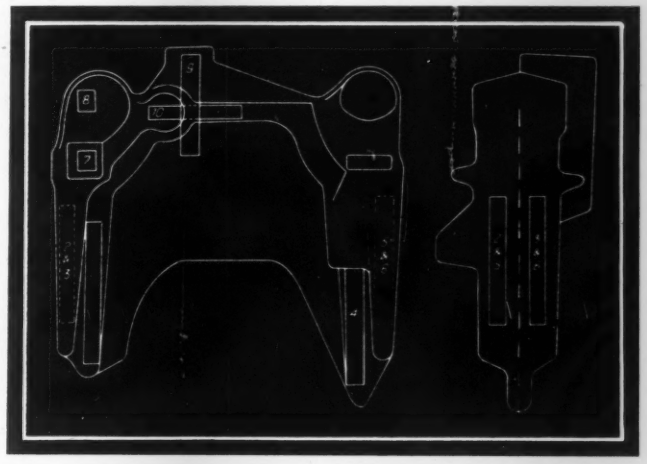
Fig. 5—Below—Finishing dies for same part. Piece produced by blocking dies is opened out prior to finishing



shape and functioning of the part in question.

Proper die design is a necessity in obtaining satisfactory grain flow in forgings. Many forging imperfections are the result of improper grain flow in the section in question. Frequently, simple changes in die design or forging technique are sufficient to correct the flow and eliminate the difficulty. It is important, therefore, that in parts subjected to high tensile and torsional stresses, and to repeated impact stresses, the grain flow follow the proper direction so as to afford the maximum strength at the point of maximum loading.

The establishment of proper flow lines in forgings can be explained best by considering a few concrete examples. *Fig.* 1 is a macroetched cross section of the hub portion of a variable-pitch propeller forging. It will be noted that the grain flow follows the forging line smoothly and without kinks. It is also important in this case that the flow lines should remain the same to such a depth that they will also conform to the finish machined contour of the propeller. Excess metal is permitted to flow freely in a



Test Bar No.	Tensile Properties T. S. Psi.	Y. S. Psi.	Per Cent Elongation	B.H.N.
1	68,100	60,200	11.5	136
2	70,000	62,000	11.0	130
3	70,600	62,700	12.0	136
4	69,600	61,500	12.0	143
5	70,600	62,400	10.0	136
6	67,900	60,900	8.5	130
7	65,900	61,700	2.5	143
8	65,000	60,800	2.5	143
9	68,600	61,300	6.5	143
10	68,300	61,000	9.0	143

Fig. 6—Outline of a 55-pound structural fitting of 14S-T alloy, showing location of test bars. Tabulation gives tensile properties of test bars from indicated locations

lateral direction, increasing the diameter of the base. This is removed during machining without disturbing the grain contour of the finished part.

Shown in *Fig.* 2 is an unusual-looking airframe structural fitting. It is shaped like a letter "Z" with a heavy section at each corner and very light connecting legs. It is obvious that this part could be produced with simple dies from a piece of plate. This would result in flow lines that would follow either the two outer legs or the center leg and cut through the other parts of the forging at an angle. Since the user specified flow lines follow-

ing all three legs because of the service loading of the part, it was necessary to develop a die design that would accomplish this result. A blank was prepared and placed in the die shown in *Fig.* 3, and the preliminary blocked piece was then forged in the blocking die shown in *Fig.* 4. It will be seen that this produces a piece with the metal for the three legs parallel to each other and in line with the flow lines of the bar stock that was used. This piece was opened out by bending the junction of the center leg with the two corners so that it was approximately the shape of the finished part and could be placed in the finishing die, *Fig.* 5. This resulted in the desired flow throughout the entire forging. With a knowledge of the service conditions, a study of this kind should be made before any forging is produced, so that the proper sequence of operations can be incorporated in the dies.

Tensile Properties Vary with Direction

Regardless of the care exercised in die design and in the use of the most satisfactory type of stock, variations in tensile properties will still exist in most forgings when tests are taken in different directions. *Fig.* 6 shows the outline of a large airframe fitting weighing about 55 pounds and produced in 14S-T alloy. The locations of ten tensile test specimens are indicated on the outline and the properties obtained from these specimens are shown in the table below the sketch. In this forging it was possible to obtain transverse bars in two directions at right angles to each other as well as to the longitudinal bars. It will be noted that the tensile strength and yield strength are about the same in all directions. However, there are large variations in the elongation. This is particularly noticeable in bars 7 and 8 which are perpendicular to the parting line of the forging and in a heavy section. Here the elongation drops off to 25 per cent of that specified for the alloy on a longitudinal test bar. This condition exists in many forgings and is not at all alarming since it does not affect the serviceability of the part, the maximum properties having been provided where they are required.

With the general outline of the finished forging determined and the sequence of operations established, there are certain rules that should be followed in the design of the forged part. Draft angles, fillets, edge radii, web thickness and general tolerances should be made as large as possible. At the same time the forging should be well proportioned and a straight parting line used wherever practical. Adherence to these rules will improve the metal flow, reduce the number of operations and increase the die life.

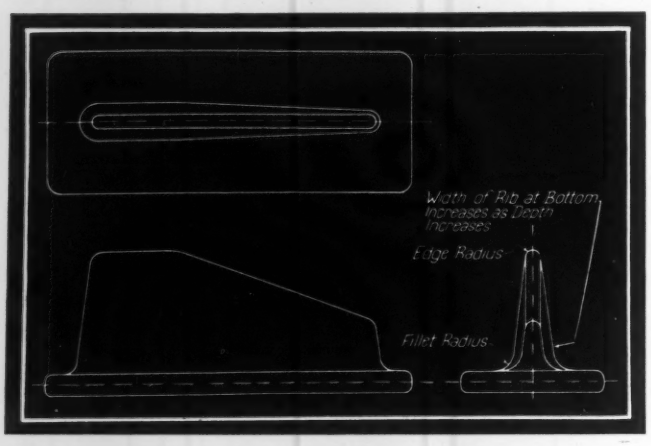


Fig. 7—Method of designing a rib of varying height so that die impression can be produced with single cutter

To facilitate the removal of the forging from the finishing die impression, a slight taper or draft is required on the side of the cavity for most types of forging. When indicating this draft on a forged part, consideration should be given to the requirements of the die sinker. Every angle on the forging must be reproduced in the steel die, therefore changing cutters too often for various draft angles or radii should be avoided. This is illustrated by the simple type of forging shown in *Fig.* 7. Here is a rib of varying height that will be finished-machined to uniform thickness. The draft angle, fillet radius and edge radius are kept constant along the entire rib so that it can be sunk in the die without changing the cutter. This results in a rib of varying thickness, but no machining difficulties are introduced and die cost is materially decreased.

When ribs or bosses are opposite each other in the two halves of the die and are not of the same height, the deeper impression should be increased so that the two sides match at the parting line. This is desirable in order to obtain a good trimming line on the forging.

Many forgings can be placed in the die so that the shape of the part produces natural draft and no additional finish is added. This should be done whenever it is consistent with good forging practice, since machining on the finished part can be eliminated in this way.

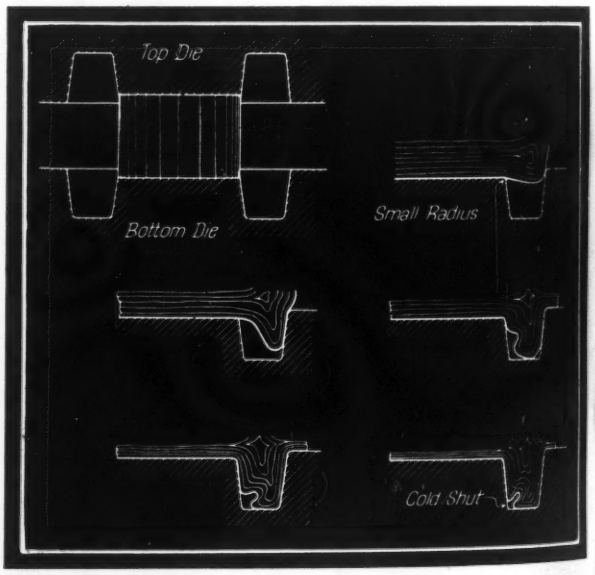


Fig. 8—Demonstration of the formation of a cold shut due to insufficient radii in the forging die

The number of forging operations necessary to convert stock to the final shape of the forging depends entirely on the design of the forged part. One of the most important rules to follow in designing forgings is that even though abrupt changes in section cannot be avoided, generous radii and fillets should always be provided. Large radii assist in the flow of aluminum in its plastic

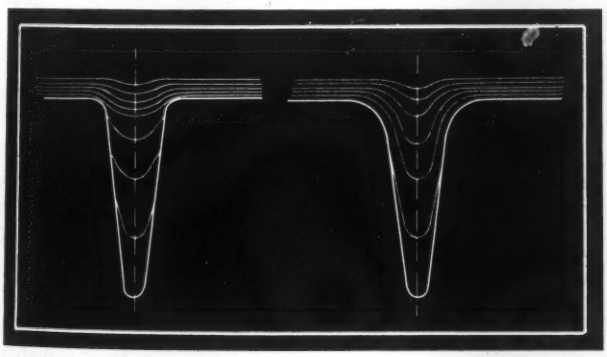
state and prevent the formation of laps, folds and other defects in the finished forging.

Statements have been made that small folds occurring in steel at high forging temperatures may weld together and disappear. In the case of aluminum alloys, however, there is always a transparent oxide film on the surface of the metal, therefore no welding of the surfaces within a fold is possible. Also there is no scaling of the surface, and the elimination of small surface defects into the scale is impossible.

A natural question for the designer to ask is "What harm can be done to a forging by the use of small radii if they are desirable in the finished part?" The series of

Fig. 9—Forging with a sharp external radius which caused a great deal of difficulty with dies

Fig. 10—Demonstration of metal flow produced by correct (right) and incorrect (left) radii at base of rib



sketches in *Fig.* 8 demonstrates the formation of a fold or cold shut in a projection on a forging because of insufficient radii. Because of the sharp corner the metal does not flow along the inside of the projection, but shoots across to the outer wall and then pivots around and flows back on itself, creating a defect.

Sharp radii on the outside of the forging, and particularly in the bottom die, have quite a different effect, but one which is equally undesirable. *Fig.* 9 shows a forging that has caused a great deal of difficulty. The design looks simple enough, but its effect on the dies is disastrous. Note the 'whiskers' and rough spots along the edge of the piece.

The die was badly checked and cracked all along the bottom corner of the impression. This condition developed after relatively short use of the die and means, of course, that a new die must be made before additional parts can be produced. The action on the die in this case may be partly due to the explosion of die lubricating oil trapped in the recess, but the principal cause of failure is the wedging action of the metal being forged. Every blow of the hammer drives the metal against the die and exerts a force which tends to split the die apart. The sharper the radius, the more concentrated and severe that force becomes and the sooner failure of the die block takes place. If the design will permit it, ribs and flanges should have full radii for longer die life and ease of filling. Where this is not possible and relatively sharp corners must be obtained, it is necessary to work out some combination of operations so that the radii are reduced without too much strain on the die block. This always entails additional impressions and increased die expense.

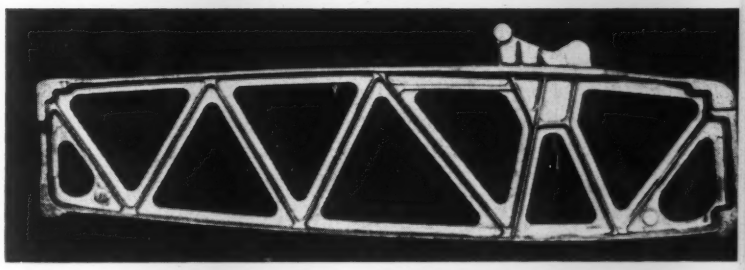


Fig. 11—Large wing support forging of 14S-T alloy. It is produced as a single piece

Effect of Sharp Radius at Base of Rib

The two sketches in *Fig.* 10 present still another answer to the question of small radii. This condition is particularly apt to occur when there are ribs on that portion of the forging next to the flash, especially in the live die. These ribs will fill before the forging is brought down to size and there is still a certain amount of metal which must be caused to flow past the rib and out into the flash. This metal, of course, moves rapidly with each blow of the hammer. With a sharp radius, the moving metal cannot change direction quickly enough to follow the surface of the forging, but continues to flow straight through the rib and comes out on the other side, thus shearing the rib away from the main body of the forging. This type of defect is aptly known as a 'flow through'. When the radius is increased as shown on the view to the right, the metal has sufficient time to follow the contour of the forging and no defect is produced.

Shrinkage, which results from the cooling of the metal after forging, causes a dimensional contraction of the

TABLE III

Shrinkage Tolerances for Aluminum Forgings

Length or Width (Inches)	Shrinkage Tolerances (Inch)	
	Plus	Minus
1	.004	.002
2	.008	.004
3	.012	.006
4	.016	.008
5	.020	.010
6	.024	.012
For each Additional Inch Add	.004	.002
For Example		
18	.072	.036
36	.144	.072
48	.192	.096
60	.240	.120

forging in all directions. The coefficient of expansion of the various aluminum forging alloys ranges between .000011 and .000015 inches per inch per degree Fahr. The shrinkage dimensions for the average aluminum forging will come within the plus and minus tolerances given in TABLE III. However, in special cases the forging will come out of the dies predominantly long. This occurs when the design calls for long forged parts with projections or heavy sections on either end and comparatively thin sections connecting them. During forging, the lighter middle sections will cool faster, but cannot shrink because the heavy end sections are locked in the die. The forging then comes out of the die at a relatively low temperature, and little shrinkage takes place. This type of forging is well illustrated by the large wing support shown in *Fig.* 11. This intricate forging was produced satisfactorily, but never worked out well in the machine shop because insufficient attention was paid to shrinkage variations. It is advisable on such a forging to make the projections at one point with standard finish allowances and then add increasing amounts of finish to the heavy sections as they occur farther away from that point. Machining layout then should be made from the same point. In this way irregularities in shrinkage are compensated for and there is always sufficient metal provided for machine finishing.

Pockets and recesses in forged parts are formed by corresponding raised sections in the dies. Therefore, pockets should not be too deep and recesses should be as simple as possible in shape. It is recommended that generous fillet radii be provided at the bottom of all pockets and recesses and that the depth of a pocket should not exceed two-thirds of its diameter.

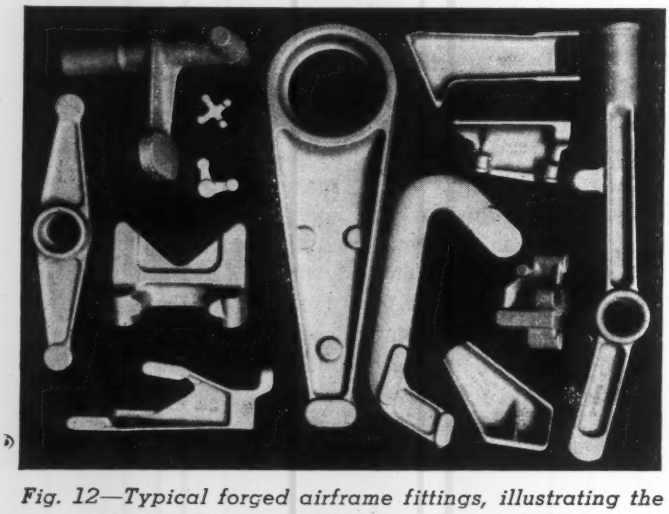


Fig. 12—Typical forged airframe fittings, illustrating the variety of sizes produced in aluminum alloys

Punch-outs are frequently introduced in hubs and bosses to facilitate the machining and boring of holes. Holes may also be punched in webs and flanges for the purpose of lightening the part or for clearance with some adjacent part. Holes in hubs and bosses are preformed during forging by the introduction of a depression in each side of the part with a web not less than ⅛-inch thick left in the forging. This web is punched out, taking care that the hole be no larger than the tangent points of the fillet radii. Holes in webs and flanges are also preformed during forging and can be punched out during the trimming operation. Usually such depressions are flashed and guttered in order to allow excess metal to escape.

Forgings made from the correct materials with good design and produced in the right way on the proper type of forging equipment represent the highest form of development of the metal working art. In other words a forging, in most applications, can accomplish the desired results with less metal than any other type of fabricated metal product. The use of a forging, then, depends upon the value to the user that he can secure by the incorporation of forged parts in his product. In many places a forging may actually be the cheapest product that can be employed, especially in large scale production, because on modern machinery, forgings can be produced so rapidly with small dimensional variations, smooth surfaces and resultant savings in finishing time. In cases where forgings are actually more expensive on the basis of total cost in the finished assembly, they may still be desirable, or even necessary, in view of the uniformly high quality of the product.

Trend Is Toward Large Complicated Forgings

The aircraft industry has been the backbone of the aluminum forging business for years and probably will continue to be the biggest consumer of forgings for some time to come. In this field the trend toward large complicated forgings will probably continue, as it should. Several years ago it was general practice for aircraft designers to specify small forged fittings which were joined by other types of structural material. Then someone put a group of fittings together and redesigned that group so that a single larger forging could be used in its place. This resulted in higher material cost, but lower over-all construction cost because of the elimination of costly assembly labor. Representative airframe fittings in a wide range of sizes may be seen in *Fig.* 12. Redesigning has resulted in a steady increase in the size of forgings until an entire wing support such as that shown in *Fig.* 11 has been produced as a single forging. These changes in the physical dimensions of forged aircraft structural parts have been made possible only by the use of large forging equipment. With the release of this equipment from war production demands, further development of new large airframe structural parts and parts for other application is expected.

Demands for war production have increased the capacity of the aluminum forging industry to such an extent that a large part of this capacity will be available for uses other than aircraft in the postwar period. Parts that are used continuously and in considerable volume are ideal. Naturally other branches of the transportation industry present the most likely field for development. Such items as railway journal bearings, truck and bus wheels and automotive axle housings are now under consideration. There is the possibility of producing complicated or large parts such as railway car truck frames and pistons for large diesel engines. Certainly there are many other applications that have not been mentioned here, so that aluminum alloy forgings will have a very intriguing future.

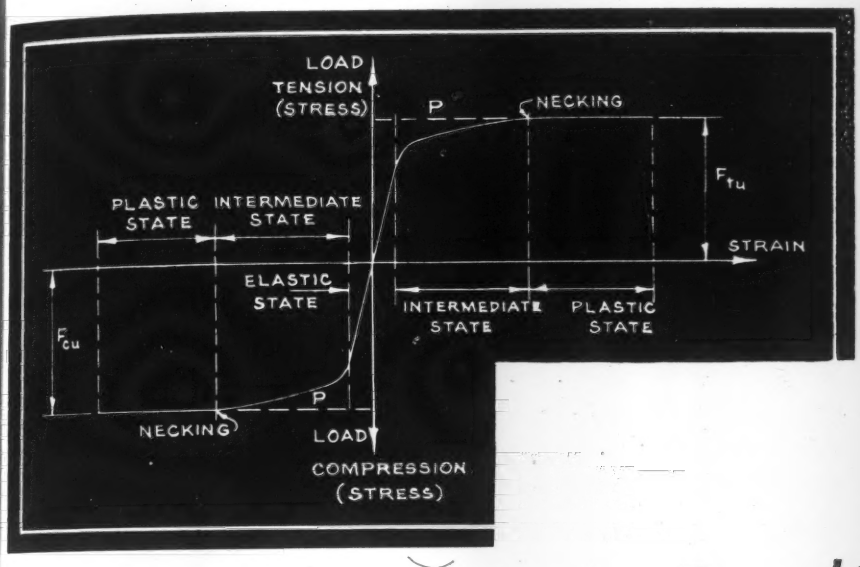


Fig. 1—Typical load-deformation curves for ductile material in tension and compression approximated by a pair of rectangles

Predicting Ultimate Failure Loads

By Leon Beskin

Consolidated Vultee Aircraft Corp.

REQUIREMENTS of modern machine and structural design, especially in the aircraft industry, necessitate the use of methods of stress analysis which can accurately predict ultimate allowable loads. Conventional methods of stress analysis derived from the theory of elasticity predict yield allowable loads. Methods deriving from the theory of plasticity can be developed to predict ultimate allowable loads and are dealt with in this article as applied to pure bending, and bending with axial loads.

When a material is subjected to a progressively increasing axial load, it generally passes through several states, *Fig.* 1. Up to the yield load it is in a state of proportional elasticity; up to the ultimate load the rate of deflection sharply increases under small increases of load; at the ultimate load, large deformations occur at practically constant load, even a decrease of load being sometimes required to obtain equilibrium (unstable). The state for which deformations are practically independent of the load is called the plastic state. If stress is defined as ratio of applied load to initial area, expression "stress" can replace "load" along the ordinates of *Fig.* 1. Thus the plastic state is defined by the fact that the stress is practically independent of the strain for a wide range of strain. A study of the consequences of the existence of that state leads to the theory of plasticity, which has been developed by Nadai* and others.

If the conditions of eccentric loading (i.e. axial loading and bending) or pure bending are examined, it can be assumed that the state of each fiber of the loaded body can be defined by a point of the curve, *Fig.* 1. A great simplification for all practical computation is obtained if that curve is replaced by two straight lines *P*, *P*, i.e. if the plastic state is extended to cover the whole range of the stress strain diagram. The theory developed on that basis will be called hereafter the rectangular theory, as opposed to the triangular theory of the conventional theory of elasticity. With this simplification, determination of ultimate allowable loads and moments can be made in a relatively simple manner, sometimes even in

*Nadai, A.—*Plasticity*, McGraw-Hill Book Co. Inc., New York, 1931.

MARGIN OF SAFETY against failure by fracture depends upon the plastic behavior of material rather than the elastic action commonly assumed in calculating working stresses. Using a simplifying assumption, the author develops equations and charts for predicting the ultimate failure loads of parts subjected to bending and to eccentric loading. For many practical computations the designer will find the essential information in TABLE II and in the discussion on Page 124 on the use of interaction curves

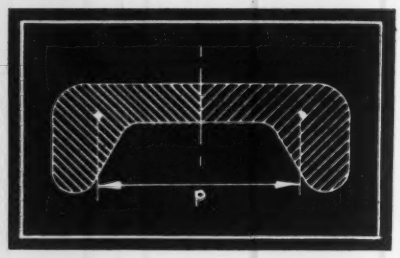


Fig. 2—Left—In plastic bending the effective line of action of the induced load is at the centroid of each half section

a simpler manner than by the conventional methods of elasticity, as will be shown in this article.

From an examination of the shape of many stress-strain curves, it is found that errors involved in this simplification are not highly important. Experimental results made for the case of pure bending definitely prove that for metals used in structural or machine design this simplification is warranted. The experimental results analyzed here are from a paper by Frank P. Cozzone†.

In rectangular theory, a symmetrical section (area A) under symmetrical bending is divided (*Fig.* 2) into two equal areas $A/2$ (it is assumed that the ultimate allowable stresses of the material in tension and compression, F_{tu}, F_{cu}, are equal). These areas are loaded with equal and opposite loads $+F_{tu}\,A/2$ and $-F_{tu}\,A/2$ and if the distance between their centroids is d, the ultimate allowable moment is $F_{tu}\,dA/2$.

TABLE I shows a comparison of theory with experimental results, where M_e = experimental ultimate allowable moment and $M_r = F_{tu}\,dA/2$ = ultimate allowable moment predicted by rectangular theory. Average values of M_e/M_r are given and show, per series of tests and for the total of 40 tests, how theory and tests compare. The following results can be noted: The average error corresponding to the rectangular theory is 2.9 per cent, while the maximum error is 9.5 per cent per series of tests, and 18.8 per cent for any isolated test.

On the basis of these experimental results, the following general method of analysis of sections under eccentric loading or pure bending can be developed (*Fig.* 3):

Divide the total section by a neutral line into two areas, one area subjected to stresses F_{tu} (resultant P_{tu}), the other area to stresses F_{cu} (resultant P_{cu}), in such manner that the resultant P_u of all stresses passes through the same point of the section as the resultant P_a of the loads applied to the section (i.e., axial load and moments in two directions), *Fig.* 3*a*. If the resultant of the applied loads is a couple M_a, the resultant of all stresses must be a couple M_u having an axis parallel to the given couple, *Fig.* 3*b*. In both cases (resultant, or resulting couple), the margin of safety is obtained by comparison of the applied axial load P_a or the applied couple M_a with the ultimate allowable load P_u or ultimate allowable couple M_u. The margin of safety is:

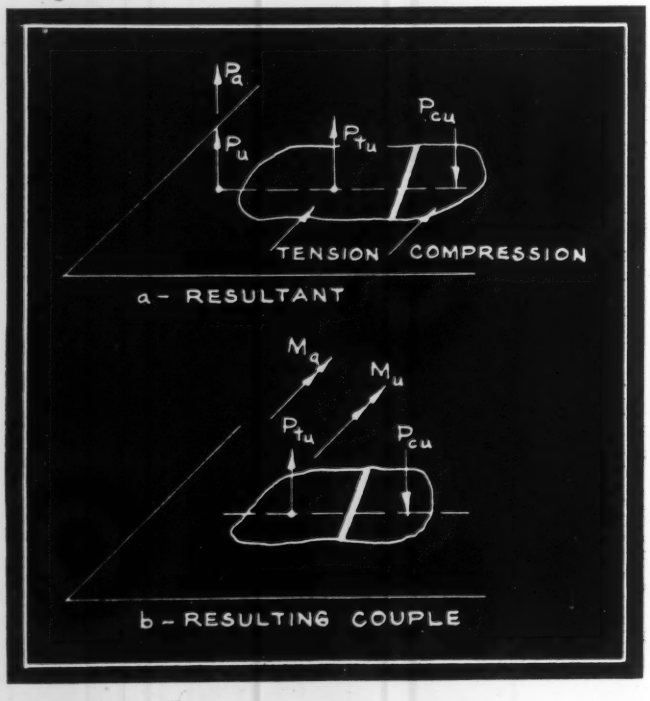
$$M.S. = \frac{P_u}{P_a} - 1 \qquad (1)$$

$$M.S. = \frac{M_u}{M_a} - 1 \qquad (2)$$

This method determines an actual distribution of stresses only when the margin of safety is equal to zero. For all other values of the margin of safety no actual stresses are defined. This fact is unimportant for the designer, since the only value required is that of the margin of safety. The actual value of stresses is important only when the total load is proportional to the maximum stress in a section. When this does not occur, as in problems of plasticity or of buckling, the determina-

†Cozzone, F. P.—*Journal of the Aeronautical Sciences*, May, 1943, Pages 137 and following. See also discussion by the author, to be published in the *Journal*, Jan., 1945.

Fig. 3—Below—Tension and compression areas for irregular section under eccentric load (a), pure bending (b)



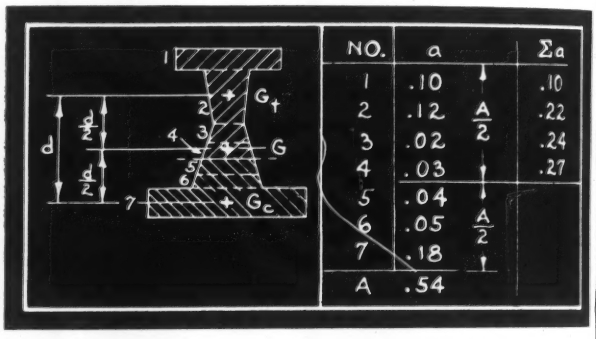


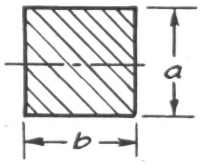
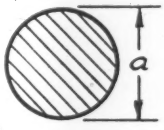
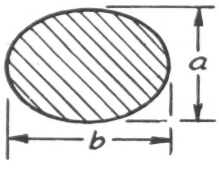
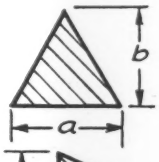
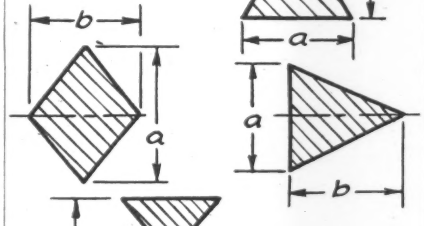
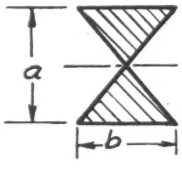
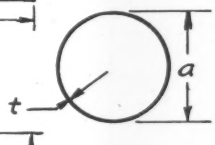
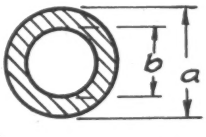
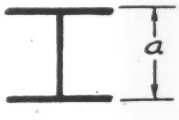
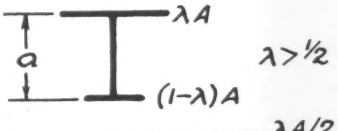
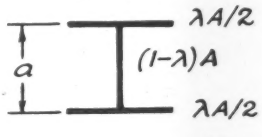
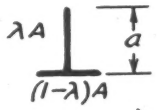
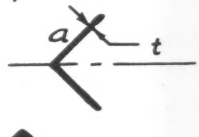
Fig. 4—How to find neutral axis for a section symmetrical about an axis perpendicular to the axis of bending

TABLE I

Ratios of Test and Calculated Ultimate Moments

Section	Material	Number of Tests	Average Values
I-Beam	14ST Forging	13	1.066
	Mg Forging	6	.979
	195-T6 Casting	4	.958
Round	14ST Forging	4	1.081
	195-T6 Casting	3	1.095
Channel	14ST Forging	5	1.052
	195-T6 Casting	5	.949
		40	1.029

TABLE II—**Modulus for Plastic (Z_p) and Elastic (Z_e) Bending**

Section	Shape	$Z_p = Ad/2$	$Z_e = I/c$	$K = Z_p/Z_e$
Rectangle		$a^2b/4$	$a^2b/6$	1.50
Round		$a^3/6$	$\pi a^3/32$	1.70
Ellipse		$a^2b/6$	$\pi a^2b/32$	1.70
Triangle		$(2-\sqrt{2})ab^2/6$	$ab^2/24$	2.343
Rhomb Triangle		$a^2b/12$	$a^2b/24$	2.00
Hour Glass		$a^2b/6$	$a^2b/8$	1.333
Thin Tube		a^2t	$\pi a^2t/4$	1.273
Thick Tube		$(a^3-b^3)/6$	$\pi(a^4-b^4)/32a$	1.273 to 1.70
I Beam		$Aa/2$	$Aa/2$	1
I Beam		$Aa(1-\lambda)$	$Aa(1-\lambda)$	1
I Beam		$(1+\lambda)Aa/4$	$(1+2\lambda)Aa/6$	1 to 1.5
Tee		$\lambda aA/2$	$\dfrac{Aa\lambda(4-3\lambda)}{6(2-\lambda)}$	1.5 to 1.8 (λ=0 to .5)
Tee		$\dfrac{aA}{8\lambda}\left(3-\dfrac{1}{\lambda}\right)$		1.8 to 1.5 (λ=.5 to 1)
Angle		$a^2t/\sqrt{2}$	$a^2t\sqrt{2}/3$	1.5
Angle		$a^2t/2\sqrt{2}$	$a^2t/3\sqrt{2}$	1.5

tion of actual stress distributions is unimportant, and only the distribution of stress at ultimate allowable conditions, which defines the ultimate allowable loads, has a practical interest.

Results established in the foregoing now will be applied to various conditions of loading and shapes of sections.

1. Bending of Symmetric Sections Around Their Axis of Symmetry—$F_{tu}=F_{cu}$: The axis of the couple being parallel to the axis of symmetry (*Fig.* 2), the latter is the neutral axis, since the half areas on both sides

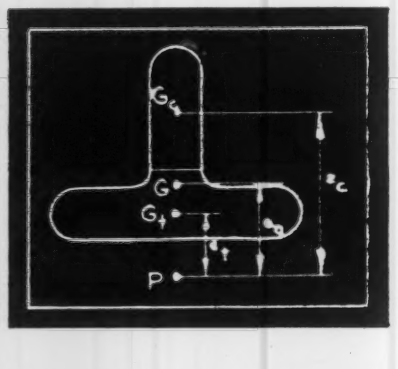


Fig. 5—Example of a section eccentrically loaded, the load being at a point on the axis of symmetry

of the axis are equal and the centroids of the half areas are, from symmetry, on a perpendicular to the neutral axis. Thus:

$$M_u=\frac{Ad\,F_{tu}}{2} \qquad (3)$$

Considering $Ad/2$ as a section modulus Z, the moment can be written

$$M_u=Z\,F_{tu} \qquad (4)$$

2. Bending of Symmetric Sections Around an Axis Perpendicular to the Axis of Symmetry—$F_{tu}=F_{cu}$: Because of symmetry, the neutral axis is perpendicular to the axis of symmetry, and defines two half areas, the centroids of which are on the axis of symmetry (*Fig.* 4). It appears that the neutral axis does not generally coincide with the centroid. For areas of complex shape, the determination of the neutral axis is made as follows: The area is divided by perpendiculars to the axis of symmetry, and elemental areas a are computed. The total area A being determined, elemental areas are summed from one end, up to the line where their sum is equal to $A/2$. The centroids G_t, G_c of each half area are then determined; their distance apart is called d, and Equations 3 and 4 can be applied. If the centroid of the total area G is known, only one centroid of half area, G_t for instance, need be determined, since $GG_t=d/2$.

3. Bending of Symmetric Sections Around an Axis Perpendicular to the Axis of Symmetry—$F_{tu}/F_{cu}=r\neq 1$: As in the previous case, the neutral axis is perpendicular to the axis of symmetry. For equilibrium under couple:

$$A_t\,F_{tu}=A_c\,F_{cu} \qquad (5)$$

where A_t and A_c are, respectively, the areas in tension and compression. Using the relations $F_{tu}/F_{cu}=r$ and $A_t+A_c=A$, it is found that

$$\left.\begin{aligned}A_t&=\frac{A}{1+r}\\ A_c&=\frac{rA}{1+r}\end{aligned}\right\} \qquad (6$$

The neutral line is determined in a similar manner to the previous case, with the difference that the partial areas are related to the total area by Equations 6. Thus when A is known, A_t (or A_c) is calculated, and a line perpendicular to the axis of symmetry, separating an area A_t (or A_c) from A, is defined. Assuming for *Fig.* 4 $r=1.25$ and tension above the neutral axis, it is found, for $A_t=A/2.25=.24$, that A_t is constituted by elements 1, 2 and 3. Then both centroids of areas A_t and A_c being determined, their distance being d, it can be written:

$$M_u=dA_t\,F_{tu}=dA_c\,F_{cu} \qquad (7$$

The section moduli may be written $Z=dA_t$ and $Z_c=dA_c$. It is to be noted that the distances d_t, d_c of the general centroid to the partial centroids G_t, G_c are such that:

$$\left.\begin{aligned}A_td_t&=A_cd_c\\ d&=d_t+d_c\end{aligned}\right\} \qquad (8$$

If one partial centroid and the general centroid are known, Equations 8 define the value of d.

Values of the section modulus Z for various sections symmetrically loaded are given in Table II. Section modulus Z_p for plastic bending and Z_e for elastic bending, as well as their ratio K, are also given. For sections having only one axis of symmetry, such as triangles, tees or angles, the shift of the neutral axis with respect to the centroid is important, and must always be taken into consideration.

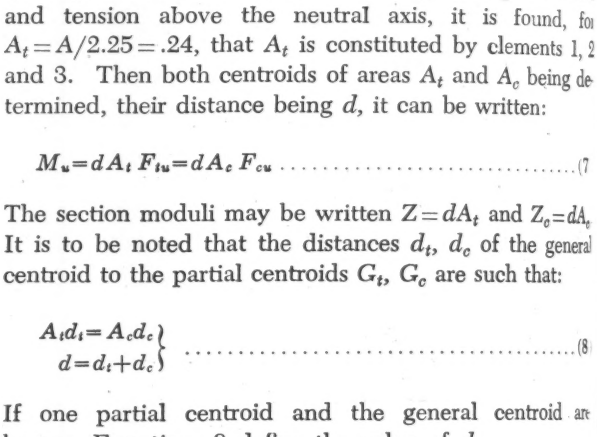


Fig. 6—Method of locating neutral axis for any section subjected to eccentric loading

4. Eccentric Loading of Symmetric Sections, the Eccentric Load Being Applied at a Point on the Axis of Symmetry—$F_{tu}=F_{cu}$: The neutral axis is perpendicular to the axis of symmetry (*Fig.* 5). In order to obtain a resultant passing through the given point P of application of the load, it is necessary that

$$A_t e_t = A_c e_c \quad \ldots\ldots (9)$$

also

$$Ae_o = A_t e_t + A_c e_c \quad \ldots\ldots (10)$$

in which e_t, e_c and e_o are the distances of the centroids G_t, G_c and G to the point P. From Equations 9 and 10

$$A_t e_t = A_c e_c = \frac{Ae_o}{2} \quad \ldots\ldots (11)$$

Method used under 2 can be applied here, with the difference that, instead of determining elemental areas, elemental static moments with respect to P must be determined. The static moment Ae_o of the total area being computed, elemental static moments ae are summed until the total equals $Ae_o/2$. This defines the neutral line. Then:

$$P_u = (A_t - A_c)F_{tu} \quad \ldots\ldots (12)$$

$$P_u = (2A_t - A)F_{tu} = (A - 2A_c)F_{tu} \quad \ldots\ldots (13)$$

5. Eccentric Loading of Symmetric Sections, the Eccentric Load Being Applied at a Point on the Axis of Symmetry—$F_{tu}/F_{tc} = r \neq 1$: Generalization of the previous case is straightforward. Equations 9, 11 and 12 are replaced by

$$A_t e_t F_{tu} = A_c e_c F_{cu} \quad \ldots\ldots (14)$$

$$A_t e_t = \frac{Ae_o}{1+r};\ A_c e_c = \frac{Ae_o r}{1+r} \quad \ldots\ldots (15)$$

$$P_u = A_t F_{tu} - A_c F_{cu} \quad \ldots\ldots (16)$$

Thus, when A and e_o are determined, the problem is reduced to finding a partial static moment $A_t e_t$ (or $A_c e_c$) satisfying Equation 15. Then Equation 16 gives the ultimate allowable eccentric load.

6. Unsymmetrical Bending of Symmetric Sections and Bending of Nonsymmetric Sections: The results obtained under 1, 2 and 3 can be applied to this case, provided the direction of the neutral axis is found. Since there is no condition of symmetry to define the direction of the neutral axis, the latter must be found by trial and error. The neutral axis is defined by the condition that the line connecting the centroids G_t and G_c of the partial areas in compression and tension must be perpendicular to the axis representing the bending moment, and by either the relation $A_t = A_c = A/2$ $(F_{tu} = F_{cu})$ or Equation 6 $(F_{tu} \neq F_{cu})$. This position of the neutral axis cannot be given in a simple manner by a direct expression as in the case of conventional bending theory; in the latter, a simple expression relates the angles formed by the neutral axis and the axis of the moment with the principal axes of the section. The trial and error method is doubly indetermined, since neither the direction of the neutral axis, nor any of its points is defined.

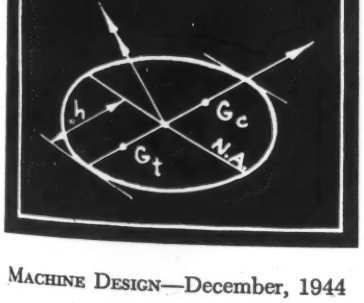


Fig. 7—For elliptic section in pure bending the line of centroids is a diameter perpendicular to direction of applied couple

7. Eccentric Loading without Symmetry: Results obtained under 6 can be extended to this case. The neutral axis is defined by the condition that the line connecting the centroids G_t and G_c must pass through the point of application of the load, and by either Equations 11 or Equations 15. Similarly to the previous case, a trial and error method must be applied, and it is doubly indeterminate.

8. Simplified Method for General Bending and Load (Eccentric Load P, Moment M): The general method of analysis contains two unknowns. A method which contains one unknown only can be developed as follows:

The point of application P of the eccentric load (eccentricity $e = M/P$) being determined (*Fig.* 6, point P), determine the area A_o required to transmit a direct load P: $A_o = P/F_u$, and

$$A_1 = \frac{A + A_o}{2}$$

$$A_2 = \frac{A - A_o}{2}$$

Lay in a series of neutral lines in various directions, all dividing the total area A into the two areas A_1 and A_2 (A_1 being on the side of P with respect to the neutral axis), and locate the centroid G_1 of A_1 areas (or G_2 of A_2 areas).

Connect lines GG_1 (or GG_2) and choose the line passing through P. On that line define the maximum allow-

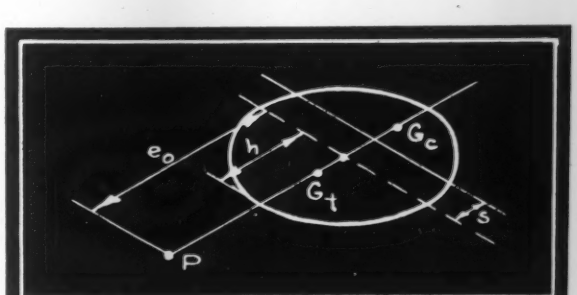


Fig. 8—Line of centroids is a diameter passing through point of application of eccentric load

able moment M_a under load P placed along that line. M_a is given by

$$\frac{M_a}{P} = \frac{2A_1 d_1}{A_o} = \frac{2A_2 d_2}{A_o} = \frac{2A_1 A_2 d}{AA_o}$$

where $d_1 = GG_1$ and $d_2 = GG_2$.

An approximate value of the margin of safety is given by:

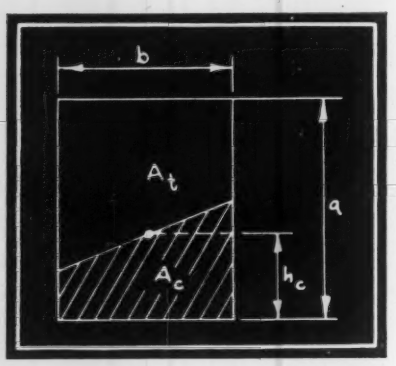


Fig. 9 — When neutral line intersects two parallel sides of rectangular section it passes through a fixed point on one axis of symmetry

$$M.S.=\left(\frac{M_a}{M}-1\right)\left(1-\frac{A_o}{A}\right) \quad \ldots\ldots (17)$$

Since an absolutely exact value of the margin of safety is unnecessary, Equation 17 will generally be satisfactory.

For several simple shapes of section, the trial and error method for conditions 6 and 7 can be simplified:

a. Elliptic section, Figs. 7 and 8. The line of centroids, $G_t\ G_c$, is a diameter perpendicular to the direction of the applied couple (*Fig.* 7) or passing through the point of application of the load (*Fig.* 8). The neutral axis has a direction conjugate to the diameter of the centroids. It is a diameter in the case of bending with $F_{tu}=F_{cu}$. This case will be examined more completely in paragraph *c*.

b. Rectangular section. The neutral line passes through a fixed point situated along one of the axes of symmetry, the position of which is defined by the value of A_t or A_c. This is valid only when the neutral line intersects two parallel sides (*Fig.* 9). Then $h_c/a=A_c/A$. Since A_t and A_c can be defined by one of the foregoing expressions, the problem is reduced to the determination of the direction of the neutral axis. This case will also be examined more completely in paragraph *c*.

c. Use of affine transformations: An affine transformation can be defined as follows: Consider (*Fig.* 10) two axes of rectangular coordinates (ox, oy), and two figures, one W defined by points (x_i, y_i), the other $\overline{W}$ defined by points $(\overline{x}_i, \overline{y}_i)$ in such manner that:

$$\overline{x}_i=K_1x_i;\ \ \overline{y}_i=K_2y_i \quad \ldots\ldots (18)$$

Figures W and $\overline{W}$ are called affine figures. It can be shown that if, instead of Equation 18, general linear relations exist between coordinates of the two figures, the transformation can be generally decomposed into an affine transformation with respect to a pair of rectangular axes called principal axes of the affinity plus a translation and a rotation. If two affine areas W and $\overline{W}$ are subjected to equal stress at corresponding points, it can be shown, by simple integration, that

$$\overline{P}=K_1K_2P;\ \overline{M}_x=K_1K_2^2M_x;\ \overline{M}_y=K_1^2K_2M_y \quad \ldots\ldots (19)$$

in which the quantities $\overline{P}$, $\overline{M}_x$, $\overline{M}_y$ correspond to the figure $\overline{W}$. Moreover

$$\frac{\overline{M}_x}{\overline{P}}=K_2\frac{M_x}{P};\ \frac{\overline{M}_y}{\overline{P}}=K_1\frac{M_y}{P};\ \frac{\overline{M}_y}{\overline{M}_x}=\frac{K_1}{K_2}\frac{M_y}{M_x} \quad \ldots\ldots (20)$$

These relations are extremely convenient when it is necessary to extend to ellipses the results found for circles (on *Fig.* 10, is shown an affine transformation between circle and ellipse with $K_1=2$, $K_2=1.5$). They are equally useful to extend to rectangles, rhombs and parallelograms the results found for squares, and also to triangles the results found in special cases (isosceles or equilateral triangles). It is generally convenient to use the centroids of areas or the points of application of loads for origins of affine transformations.

Since applied or ultimate allowable moments and loads are transformed by Equations 19 in an affine transformation, and their ratios are transformed by Equation 20, if for one figure an interaction equation of the type

$$E(R_{bx}, R_{by}, R_a)=0 \quad \ldots\ldots (21)$$

is known, in which

$$R_{bx}=\frac{M_x}{M_{xu}};\ R_{by}=\frac{M_y}{M_{yu}};\ R_a=\frac{P}{P_u} \quad \ldots\ldots (22)$$

Equation 21 will apply for any figure deduced from the given figure by any affinity having the axes x, y as principal axes, and $\overline{M}_{xu}$, $\overline{M}_{yu}$, $\overline{P}_u$ will be deduced from M_{xu}, M_{yu}, P_u by Equations 19. For instance, for a circle it is obvious that the ultimate moment is the same in all directions. The interaction equation is thus:

$$M_x^2+M_y^2=M^2=M_u^2=M_{xu}^2=M_{yu}^2 \quad \ldots\ldots (23)$$

or:

$$R_{bx}^2+R_{by}^2=1 \quad \ldots\ldots (24)$$

The same equation applies to the ellipse; however M_{xu} and M_{yu} are different from one another. Since for a circle of diameter a, the ultimate allowable moment M_u is equal to $a^3F_{tu}/6$ (assuming $F_{tu}=F_{cu}$), it appears that, using Equations 19:

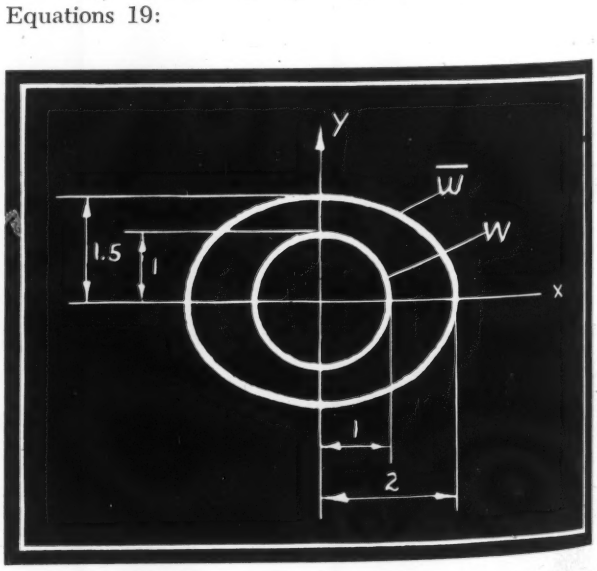


Fig. 10—Transformation between circle and ellipse illustrates extension of results found for one shape to another. Method can be applied to other shapes

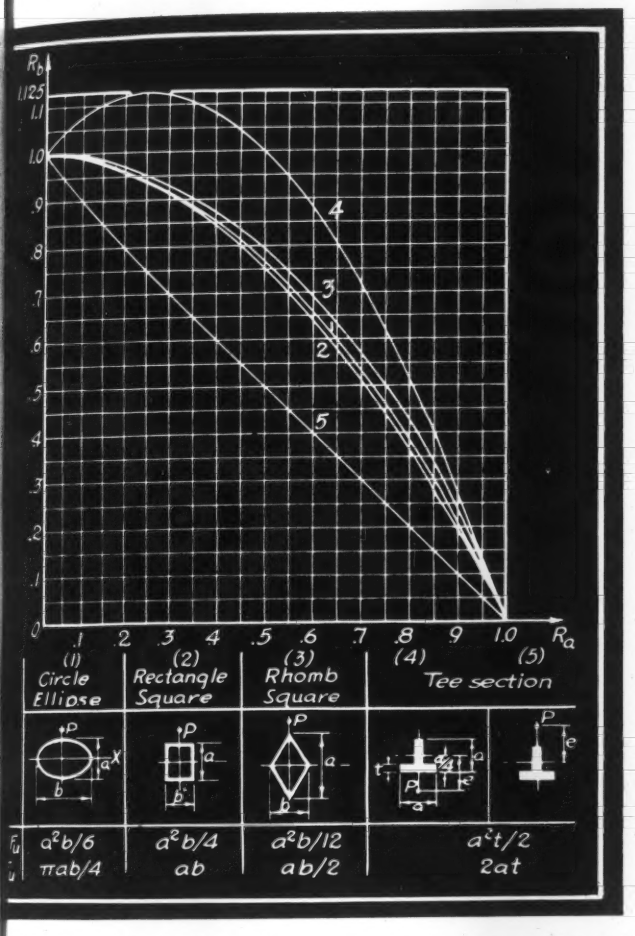


Fig. 11—Above—Interaction curves for bending and axial load for simple sections with load located as shown

$$M_{xu}=\frac{ab^2F_{tu}}{6};\quad M_{yu}=\frac{a^2bF_{tu}}{6} \qquad (25)$$

in which a and b are the principal axes of the ellipse along the x and y axes respectively.

For any section, a chart can be made, giving the value of M_u as a function of the polar angle defining the direction of the applied moment. It is generally more convenient to use the method of interaction equations. In the case of circular or elliptic section, Equation 24 applies. For other sections, Equation 24 gives a good approximation, at least in general. Several interaction curves are given on *Fig.* 12, corresponding to the following conditions:

1. Circle and ellipse:

$$R_x^2+R_y^2=1$$

2. Square and rectangle:

$$R_y+\frac{3}{4}R_x^2=1\,(R_y>R_x)$$

$$R_x+\frac{3}{4}R_y^2=1\,(R_x>R_y)$$

3. Rhomb:

$$2(R_x+R_y)+(R_x-R_y)^2=3$$

4. Triangle, placed as shown (accurate within 1 per cent):

$$R_x^2+R_y^2=1$$

5. Angle with equal legs, placed as shown:

$$R_y+R_x^2=1$$

For combined bending and axial load (eccentric load), interaction curves are given in *Fig.* 11 for the following conditions:

1. Circle and ellipse, eccentricity along a principal axis:

$$R_a=\frac{2\theta+\cos 2\theta}{\pi}$$

$$R_b=\cos^3\theta$$

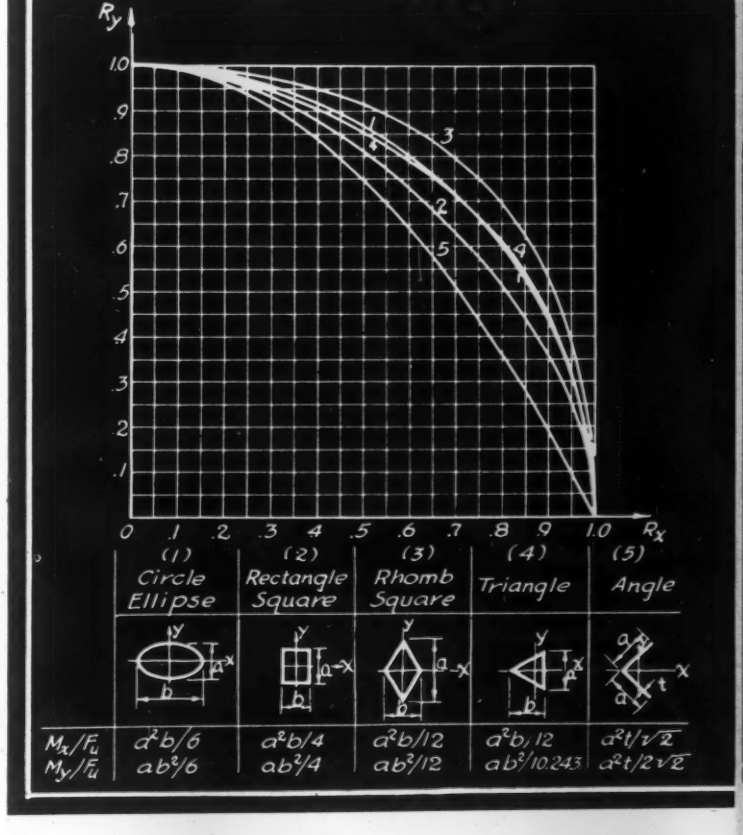
where θ is a parameter which for the circle (diameter a) is such that $a\cos\theta/2$ is the distance of the neutral axis to the center.

2. Square and rectangle, eccentricity along an axis: Angle with equal legs, eccentricity along the axis of symmetry:

$$R_a^2+R_b=1$$

3. Square and rhomb, eccentricity along a diagonal:

Fig. 12—Below—Interaction curves for bending in two directions, for a number of simple sections



$$R_a = x(2-x)$$

$$R_b = (1+2x)(1-x)^2$$

where x is the ratio of the distance between the neutral axis and the center to the half diagonal of the square or the rhomb.

4. Tee with equal legs, eccentricity along the axis and opposite the outstanding leg:

$$R_b + 2R_a^2 - R_a = 1$$

5. Tee with equal legs, eccentricity along the axis and toward the outstanding leg:

$$R_a + R_b = 1$$

Because of the dissymmetry of the profile with respect to the line along which eccentricities are taken, there are

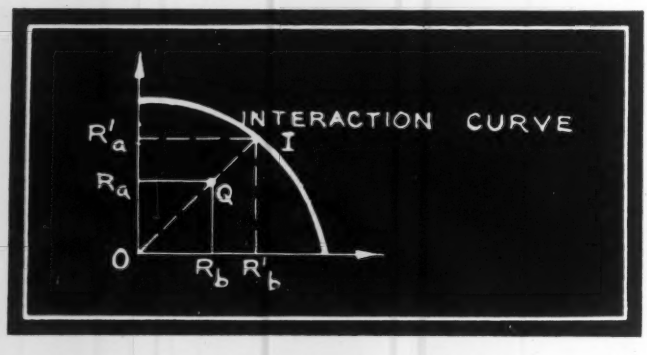


Fig. 13—Use of the interaction curve to find the margin of safety against ultimate failure

two curves. The average of values R_b for a given R_a coincides with condition 2.

USE OF THE INTERACTION CURVES, MARGIN OF SAFETY: In general, the following interaction formulas can be used:

Bending in two directions:

$$R_{bx}^2 + R_{by}^2 = 1$$

Bending and axial load (eccentric load)

$$R_a^2 + R_b = 1$$

Axial load and combined bending:

$$R_a^2 + \sqrt{R_{bx}^2 + R_{by}^2} = 1$$

In these expressions:

$$R_a = \frac{P}{P_u} = \frac{P}{AF_u}$$

$$R_b = \frac{M}{M_u} = \frac{M}{ZF_u}$$

$$R_{bx} = \frac{M}{Z_x F_u}$$

$$R_{by} = \frac{M}{Z_y F_u}$$

Also A = total area, Z, Z_x and Z_y are section moduli in plastic bending in various directions. It is assumed that the same ultimate stress F_u is used both for tension and compression.

Margins of safety can be determined from the values of two ratios R_a, R_b, for instance, and the interaction curve, in the following manner (*Fig.* 13):

Plot the Point Q (R_b, R_a). Draw OQ which intersects the interaction curve at I. The margin of safety is given by any one of the following relations:

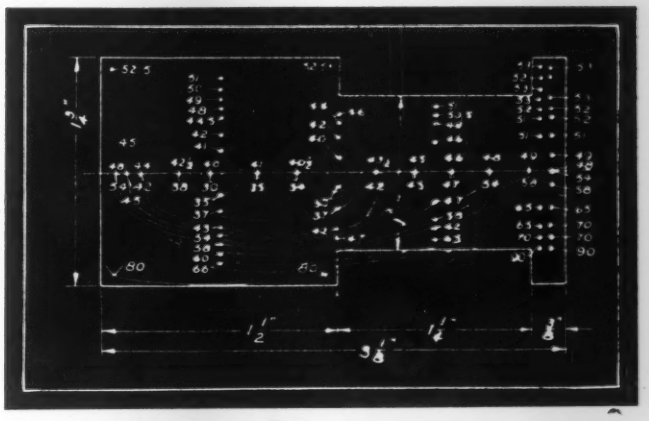
$$M.S. = \frac{OI}{OQ} - 1 = \frac{OR'_a}{OR_a} - 1 = \frac{OR'_b}{OR_b} - 1$$

For certain interaction formulas, equations for margins of safety follow:

Interaction Equation	Margin of Safety
$R_1 + R_2 = 1$	$\frac{1}{R_1+R_2} - 1$
$R_1^2 + R_2^2 = 1$	$\frac{1}{\sqrt{R_1^2+R_2^2}} - 1$
$R_1^2 + R_2 = 1$	$\frac{2}{R_2+\sqrt{R_2^2+4R_1^2}} - 1$
$\frac{3}{4}R_1^2 + R_2 = 1$	$\frac{2}{R_2+\sqrt{R_2^2+3R_1^2}} - 1$
$2(R_1+R_2)+(R_1-R_2)^2 = 3$	$\frac{3}{R_1+R_2+2\sqrt{R_1^2+R_2^2-R_1R_2}} - 1$

SHEAR STRESS AND PLASTIC DISTRIBUTION: It is impossible to present a theoretically exact analysis of the influence of shear on ultimate allowable bending moments, since the effect of shear on the ultimate allowable axial stress F_u is not very well known. Moreover, in bending with shear, the moment varies along the axis and the distribution of axial stresses also varies. This causes axial stresses in directions parallel to the plane of the section. Thus there are stresses in all directions, which precludes an exact analysis. Moreover, shear is far from being uniform through the width of thick sections, for which the present theory is specially adapted.

Since the designer is interested only in a margin of safety, it seems advisable to use an average shearing stress on the area (except when a notable reduction of thickness near the middle region of the section warrants a coefficient of increase in shear), and to combine this shearing stress with the uniform axial stress by whatever interaction formula for shear-axial load is used for a given problem.



Selecting Steel on the Basis of Hardenability

By A. L. Boegehold

Research Laboratories Division
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Part II—Hardness-Cooling-Rate Patterns

THERE is much to be said about selecting a steel to meet a desired hardness requirement in an article of irregular shape. Cooling rates in various size rounds and plates as shown in *Figs.* 8, 9, and 10[1] have been measured by means of thermocouples so that where the article to be made is represented fairly closely by one of these simple shapes, the published cooling rates can be used to determine what kind of steel to select.

Irregular shaped objects, however, frequently are of such shape that cooling rates cannot be estimated or calculated closely enough for guidance in selecting the proper steel. There are two ways of determining these cooling rates. One way is to attach thermocouples to the article at points of importance stresswise and actually measure the temperature change during quenching from the hardening temperature. This method is cumbersome and requires equipment and technique that few plants possess. The other method can be carried out readily at any plant, because it involves only the determination of hardnesses throughout the article after quenching from the hardening temperature, and then substitution of cooling rates corresponding to those hardnesses picked from a hardenability curve for the same steel.

To illustrate the procedure, the various steps will be described in connection with the spool-shaped object shown in *Fig.* 15. The method described will apply to any other shaped object such as a steering knuckle, transmission gear or other highly stressed component. This method was first described by the author[2] prior to the adoption and standardization of the Jominy hardenability test in 1941 by S.A.E.

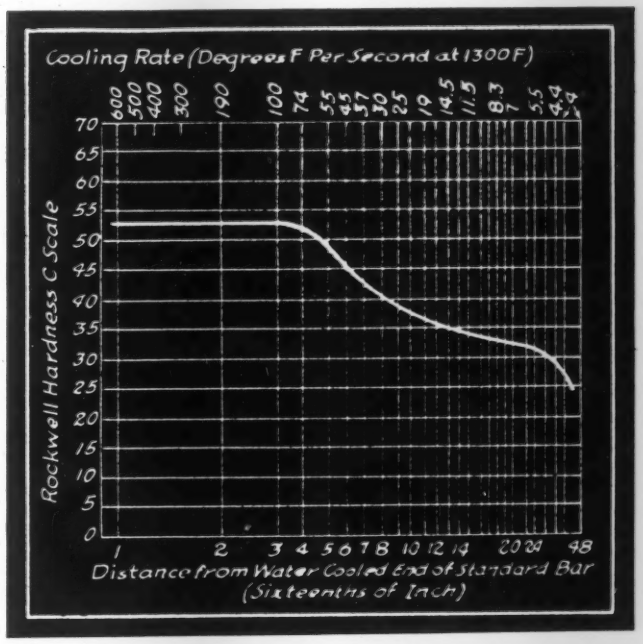


Fig. 15—Top—Cross section through spool-shaped part of 5130 steel. Rockwell C hardness readings are indicated above center line. Corresponding cooling rates in degrees Fahr. per second at 1300 degrees Fahr. are shown below center line. Immediately above is 5130 hardenability curve from which cooling rates in spool were picked

The object is to find out what steels will produce certain required hardnesses at various points in the spool-shaped article. First, determination must be made as to what cooling rates occur when the article is quenched from the hardening temperature in the selected quenching medium. To do this, the spools must be made of a steel in which full hardening will occur only at the edges

Abstract of a paper presented at a recent Metropolitan Section meeting of the Society of Automotive Engineers in New York.

[1] See Part I, MACHINE DESIGN, November, 1944.

[2] Boegehold, S.A.E. *Transactions*, Vol. 49, No. 1, Pages 226-276, July, 1941.

and corners, thus insuring a wide range of hardnesses in the spool from surface to center after hardening. In this instance the spool was made of SAE 5130 steel. It was heated to 1675 degrees Fahr. and quenched in oil. Then it was sectioned longitudinally and the hardness measured at various points. A hardenability test bar was made from the same bar of 5130 steel and also heated to 1675 degrees Fahr. prior to end quenching.

Hardnesses on the cross section of the spool after hardening and the hardenability curve for 5130 steel are shown in *Fig.* 15. Cooling rates corresponding to the hardnesses shown on the cross section of the spool were picked from the hardenability curve and located on the lower half of the spool cross section in the same positions as the corresponding hardnesses. Points of identical cooling rates are connected by lines, forming contours of equal cooling rates. This procedure reveals the cooling rates that occur when the spool is quenched from 1675 degrees Fahr. in oil. If it is desired to know the cooling rates when the spool is quenched from some other temperature or in some other quenching medium, the process may be repeated, being sure each time that the spool and the hardenability test bar are both heated to the same temperature and that both have the same treatment, if any, prior to hardening. Any difference in the composition or treatment between the hardenability bar and the object being investigated will produce erroneous results.

Having determined the cooling rates in the spool when oil-quenched from 1675 degrees Fahr., it can be determined from the hardenability curve of any other steel what hardness that steel would produce in the spool if quenched from 1675 degrees Fahr. If the hardness required in the spool is known, it becomes a simple matter to select the steel which will produce that hardness in the spool. The cooling rates occurring in the spool when it is quenched, coupled with certain hardnesses required at known cooling-rate locations, provide a series of hardness-cooling-rate pairs which will define a hardness-cooling rate curve. The steel that satisfactorily meets the hardness requirements for the spool then will have a Jominy hardenability curve having the same hardness-cooling-rate pairs.

To illustrate this principle, let us assume certain requirements as to hardness in the spool, and consider three examples. In the first two examples the part is to be subjected to stresses which will require in the quenched and tempered part a hardness of 32 to 36 rockwell C. Those who insist on obtaining substantially full hardening throughout the part prior to tempering will require a hardness of 50 rockwell C minimum in the as-quenched condition. Those who will accept a lower internal hardness, so long as it is higher than the hardness desired after tempering, might specify 40 rockwell C minimum throughout and 50 rockwell C minimum to a depth of ¼-inch below the surface.

In the third example, assume a part is to be case-carburized in which 60 rockwell C is required to a depth of .025-inch and 30 rockwell C is required as the minimum core hardness. The hardness requirements in these three examples then are as follows:

Example 1. 50 rockwell C minimum throughout.

Example 2. 50 rockwell C minimum ¼-inch below surface, 40 rockwell C minimum throughout.

Example 3. 60 rockwell C minimum .025-inch below surface, 30 rockwell C minimum throughout.

These hardness requirements coupled with the cooling rates known for the locations in the spool at which hardness is specified, give hardness-cooling-rate points on the Jominy hardenability curve as shown in TABLE III. With this information the curves shown in *Fig.* 16 can be drawn. They will represent steels that can meet the requirements of the three examples.

Fig. 16—Hardenability curves drawn to meet the requirements of examples 1, 2 and 3 discussed in article

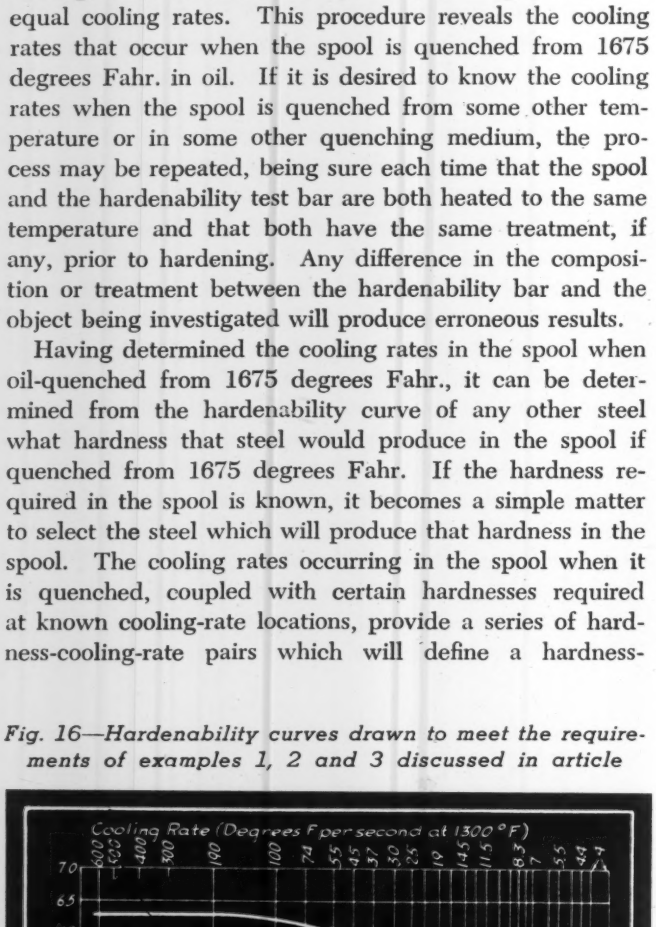
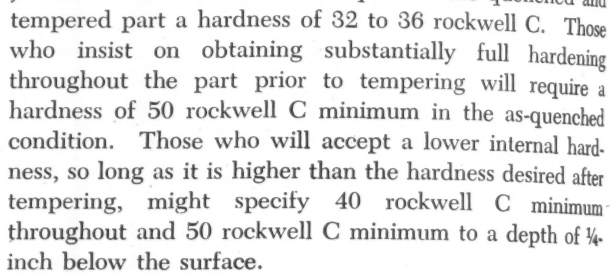


Fig. 17—Curves define hardenability limits for gear of example No. 4. They may be expressed as 37 to 47 rockwell C at 1/16-inch, 4/16 to 8/16 at J-30 rockwell C



Curve No. 1 meets the requirement of example No. 1 and represents the minimum hardenability that will be satisfactory. Any steel having greater hardenability will be suitable and will have a hardenability curve passing through or lying above 50 rockwell C at 8/16-inch from the quenched end. The shape of the curve after it falls below 50 rockwell C does not matter because the spool is not cooled anywhere at a slower rate than that occurring at 8/16-inch from the end of the Jominy bar.

TABLE III

Hardness-Cooling-Rate Requirements

Example Number	Specified Hardness (rockwell C)	Cooling Rate (deg per sec)	Equivalent Distance from Quenched End of Jominy Test Bar (sixteenths of an inch)
1	50 (center)	30	8
2	50 (¼-in. below surface)	40	6½
	40 (center)	30	8
3	60 (case)	58	5
	30 (core)	30	8

Curve No. 2 represents the hardenability of a steel that meets the requirements of example No. 2. It has only slightly less hardenability than the steel represented by curve No. 1 and yet would be unsatisfactory for the requirements in example No. 1. Any steel satisfactory for example No. 1 would be satisfactory for example No. 2, but steel suitable for example No. 2 would not be satisfactory for example No. 1.

Two curves No. 3 are needed, one for the case and one for the core. They represent the minimum hardenability that will meet the requirements of example No. 3. The curve for the core must lie above 30 rockwell C as far as 8/16-inch from the end of the Jominy bar. Any hardness above 30 rockwell C in this part of the curve would meet the specification. So far as the specification given in the example goes, the steel represented by curve No. 1 would be satisfactory. In actual practice, however, additional requirements would have to be imposed to limit the hardness that would occur at cooling rates faster than 30 degrees per second. This is done by specifying the carbon content limits and will be discussed in greater detail later.

Curve No. 3 for the carburized case meets the requirement that at least 60 rockwell C be obtained with as low as 58 degrees Fahr. per second cooling speed at .025-inch below the surface of the spool where the 1-inch diameter section joins the 1¾-inch diameter part of the spool. At all other places on the spool the cooling rate at .025-inch below the surface is faster than 58 degrees Fahr. per second.

In the selection of steel to be used for determining cooling rates in articles to be heat treated, the article to be explored for cooling rates should be made from a steel of lower hardenability than normally would be used for the actual part so that full hardness is obtained only at edges and corners where the cooling rate is fastest. The rest of the article will vary considerably in hardness, depending on the cooling rate. If the article is made of a steel of high hardenability the cooling rates will not be revealed because maximum hardness will be obtained throughout. (All cooling rates result in the same hardness for a high-hardenability steel.)

For illustration, refer to the spool-shaped object shown

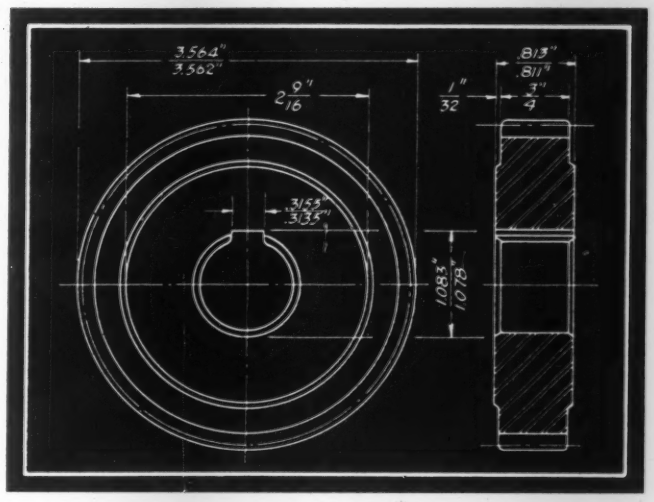


Fig. 18—Cooling rates and corresponding hardnesses throughout this gear are given for X-5145, 5040 and 5030 steels in TABLE VII. Fig. 19 gives hardness locations

in *Fig.* 15. When made of 5130 and oil quenched from 1675 degrees Fahr. the hardness varied from 40 to 53 rockwell C. According to the hardenability curve for this steel any cooling speed faster than 90 degrees Fahr. per second results in 53 rockwell C—no harder. Where the hardness in the spool is 53 rockwell C, all that is indicated is that the cooling rate was at least 90 degrees Fahr. per second. It is obvious from the shape of the piece that those regions near the periphery of the flanged end that are 53 rockwell C cooled faster than places nearer the axis of the piece which also were 53 rockwell C. How much faster the outer portion cooled cannot be determined with 5130 steel because the hardness-cooling rate curve is flat above 90 degrees Fahr. per second.

Check Test Is Necessary

When the method herein described has been used to determine a steel that will quench to certain required hardness values in some object, the natural procedure is to produce the object from the selected steel to check the accuracy of the prediction. All conditions that influence cooling rates must be maintained in the check-test the same as they were when cooling rates in the object were first determined. Also, the steel selected for the check-test should be from the same bar as that from which the hardenability test bar was made and the heat treatment of the object when made from the selected steel must be the same as was used for the hardenability bar on which the prediction was based. Any violation of this principle will result in failure to obtain the hardnesses predicted. A list of factors that affect the rate of cooling and hardenability of steel is given in TABLE IV. It is these factors that must be kept the same in the process of proving out the accuracy of hardness predictions if reliable results are expected.

It seldom is practical to specify a steel on the basis of a minimum hardenability curve without supplementing the specification with chemical composition limits. The use of a minimum hardenability curve along with a chemical composition specification provides definite limits on

maximum hardenability as will be seen later. In some cases it is desirable to place more restrictive limits on hardenability by specifying a minimum and maximum hardenability curve. This more often is a necessity when the article is to be carburized and is of such shape that considerable change in section and, therefore, in cooling rates, occurs in the article.

TABLE IV

Factors Affecting Cooling Rate and Hardenability

Factors Affecting Cooling Rate	Factors Affecting Hardenability
Kind of quenching medium	Heating temperature (grain size effect)
Temperature of quenching medium	Prior treatment (effect on carbides)
Circulating speed of quenching medium	Heating rate (effect on carbides)
Size and shape of object	Composition
Quantity and kind of scale on object	Grain size
Temperature of object quenched	Unknown composition factors

For example No. 4, consider a gear such as a transmission gear. Cooling rates may be determined by the process illustrated in the case of the spool. Assume that the important locations in which hardness must be controlled within limits are known and that those limits are as shown in TABLE V.

These requirements give three hardness-cooling-rate pairs or hardness-sixteenths pairs which define two limiting curves as shown in *Fig.* 17. These two curves could be described in a specification in two different ways. Either by specifying a hardness range at three different

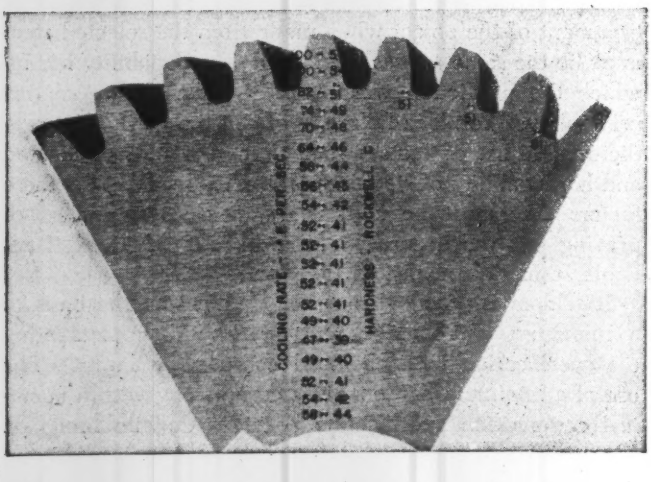
TABLE V

Hardenability Requirements in Gear

Hardness Control Location	Cooling Rate at Control Location (deg per sec)	Equivalent Distance on Jominy Bar (sixteenths of inch)	Hardness Range Desired (rockwell C)
.08-inch below surface of tooth	200	2	35-45
Center at base of tooth	80	4	30-40
Center of hub	50	5½	25-35

points on the Jominy bar or by specifying a hardness range at the 1/16-inch point and a maximum and minimum distance from the quenched end at a reference hardness number. The reference hardness number is determined by the carbon content range of the steel as is the hardness range at 1/16-inch from the quenched end.

Fig. 19—Hardness traverse of gear section. Cooling rates were picked from hardenability curve for 5040 steel



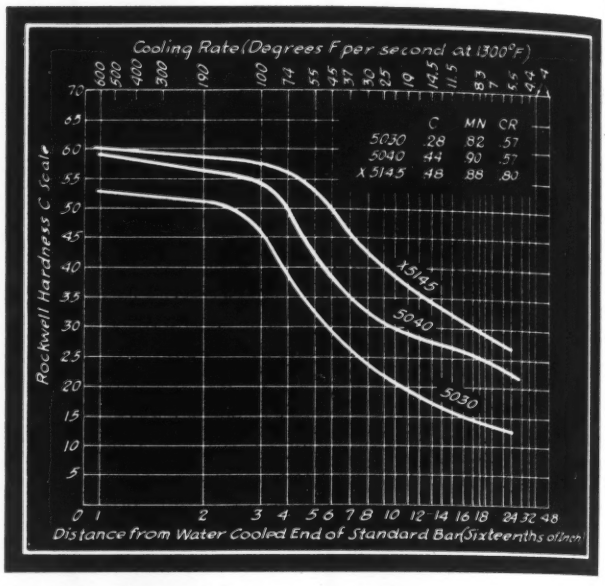


Fig. 20—Hardenability curves of three gear steels. Cooling rates in Fig. 19 were picked from curve of 5040 steel

The first method would express the curves:

35 to 45 rockwell C at 2/16-inch
30 to 40 rockwell C at 4/16-inch
25 to 35 rockwell C at 5½/16-inch

The second method would express the curves:

37 to 47 rockwell C at 1/16-inch
4/16-inch to 8/16-inch at J-30 rockwell C

At the moment, industry is in favor of the latter method of expressing these curves. The carbon range required to meet the specification of 37 to 47 rockwell C at J-1/16-inch as determined from curves in *Fig.* 7, would be .15 to .17 per cent carbon, but this is not a commercially practical limit. It is only the occasional heat that hardens at the 1/16-inch point up to the maximum hardness represented by the upper curve. Practically, the carbon limits can be held at the conventional 7 or 8-point range and still come within the 10-point hardness spread. Where more precise control is required it becomes necessary to select heats to come within the prescribed limits.

TABLE VI

Hardness Reference Numbers for Specifying Hardenability Limits

Carbon Range	Hardness Reference Number (rockwell C) Alloy Steel	Plain Carbon Steel
.08 to .12	25	..
.13 to .17	25	..
.18 to .22	30	25
.23 to .27	35	30
.28 to .32	40	35
.33 to .37	45	40
.38 to .42	45	40
.43 to .47	50	45
.48 to .52	50	45
.53 to .57	55	50
.58 to .62	55	50

Reference hardness numbers to be used in specifying points on hardenability curves have been determined from a study of the hardenability curves for 1400 heats collected by the S.A.E.-A.I.S.I. Hardenability Committee. These reference hardness numbers as decided upon by the S.A.E. War Engineering Board Iron & Steel Committee are shown in TABLE VI.

A mechanical drawing of a rear unit center gear for the

Hydramatic transmission is shown in *Fig.* 18. The gear and a Jominy test bar were both made from the same bar of SAE 5040 steel. The hardenability curve obtained from the Jominy bar provided the relation between cooling rate and hardness necessary for determining cooling rates in the gear. The gear made from 5040 steel was heated in activated salt at 1525 degrees Fahr. and quenched in oil of 80 to 100 seconds viscosity at 100 degrees Fahr. The hardness traverse from outside to center was made and is shown in *Fig.* 19. Alongside the hardness figures are shown the cooling rates picked from the hardenability curve for 5040 steel shown in *Fig.* 20. Also shown in *Fig.* 20 are hardenability curves for X-5145 and 5030, one with higher alloy and carbon content than 5040 and the other with lower carbon than 5040. TABLE VII shows the cooling rates determined for the gear, along with corresponding hardnesses for the three steels.

From the hardness information in TABLE VII it is concluded that 5040 steel, having the hardenability of the particular heat investigated, gives just about the hardness distribution desired for this particular gear. Very little tempering is necessary to avoid brittleness, therefore the hard surface layer from the activated salt bath is maintained full hard. X-5145, however, results in so much higher hardness that a higher tempering would be necessary to reduce the hardness and brittleness, thus sacrificing some of the surface hardness obtained from carburizing in the activated bath. On the other hand, 5030 would probably be unsatisfactory because of excessively low hardness and strength in the gear teeth.

TABLE VII

Cooling Rates and Hardnesses

Cooling Rate (deg F/sec at 1300 F)	Hardness (rockwell C) X-5145*	5040	5030*
100	57.5	54	46
82	57	52	42
74	56	49	39
70	56	47.5	38
64	55	45	36
58	54	43	34
56	53.5	42.5	33.5
54	53	42	33
52	52	41	32
49	51.5	40	31.5
47	50.5	39	30.5

* Hardnesses predicted from hardenability curve and cooling rates estimated by substitution in 5040 gear.

Each steel specification has a range of hardenability that can be represented by a band defined by a maximum hardenability curve and a minimum hardenability curve. In example No. 1 a minimum hardenability of 8/16-inch at J-50 was specified. The steel specified to meet that requirement then must have the low side of the hardenability band pass through 8/16-inch at 50 rockwell C.

TABLE VIII

Hardenability Band Ranges

Steel	Range at 50 rockwell C —(sixteenths on Jominy bar)— min	max
3240	9	32
8750 or 8650	8½	29½
9450	8	48
9540	24	48
4150	11	48

Only a few steels would meet such a specification, among them being 3240, 8650, 4150, 9450 and 9540. The hardenability of these five steels will vary between the low and high limits shown in TABLE VIII on account of variation in chemical composition within the limits standard for each steel.

The hardenability bands defined by the limits in TABLES VIII, IX and X were determined by means of the S.A.E.-A.I.S.I. survey of 2000 heats of steel. *Fig.* 21 shows the range or bank of hardenability that can be expected in connection with 8650 and 8750 steel. It should be observed that the low side of the band passing through 8½ sixteenths at 50 rockwell C slightly exceeds the specification for example No. 1.

In example No. 2 the minimum hardenability specified was 6½ sixteenths at 50 rockwell C. Only two steels on which hardenability bands are available in addition to those in TABLE VIII will meet this specification. They are shown in TABLE IX.

TABLE IX

Hardenability Band Ranges

Steel	Range at 50 rockwell C —(sixteenths on Jominy bar)— min	max
5150	7	14
6150	7	16

In example No. 3 the carburizing steel was required to have a minimum of 8/16-inch at J-30 rockwell C. The steels on which we have records of hardenability bands do not show any band minimum high enough to meet

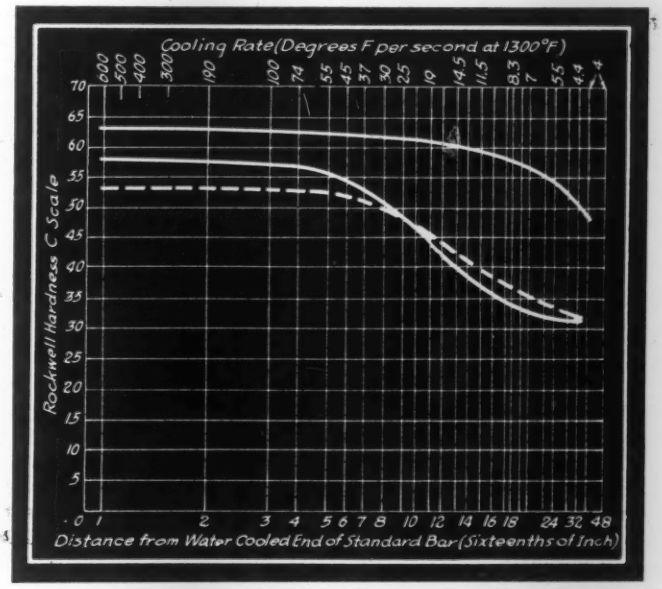


Fig. 21—Solid lines define maximum and minimum limits for hardenability of 25 heats of 8650 and 8750 steel. Broken line shows minimum hardenability that will meet requirements of example No. 1 discussed in article

this specification. The nearest approach to meeting this requirement is 4820 which has a spread of from 7/16-inch to 32/16-inch at J-30 rockwell C.

Example No. 4, which is typical of a frequently stipulated requirement, limits the hardenability to a maximum as well as a minimum. The hardenability limits are set for the purpose of maintaining the rockwell hardness within a 10-point range at several points in the core of a carburized gear. None of the carburizing steels of stand-

ard chemical ranges will have all heats falling within the hardenability band specified which was 4/16 to 8/16-inch at J-30 rockwell C. Some typical hardenability bands resulting from the S.A.E.-A.I.S.I. hardenability committee work are shown in TABLE X.

It should be explained that the hardenability variation shown in TABLE X applies to quenching from the carburizing temperature. The hardenability spread encountered within the number of heats examined could be reduced by quenching from a lower temperature as is sometimes done to refine the case and obtain maximum case hardness. The metallurgist has recourse to manipulation of heat treating temperatures in order to maintain the hardness of carburized parts within specified limits to compensate for hardenability variations from heat to heat. For example, with the spread in hardenability shown by 4620 steel in TABLE X, quenching from the carburizing temperature would result in a hardness variation from 18 to 45 rockwell C at any point in the quenched article having a cooling rate of 100 degrees Fahr. per second.

TABLE X

Hardenability Band Ranges

Steel	Range at 30 rockwell C (sixteenths on Jominy bar) min	max	No. of Heats Tested
3310	3	26	63
4620	1	14	35
4820	7	32	26
8720 and 8620	2	10	179

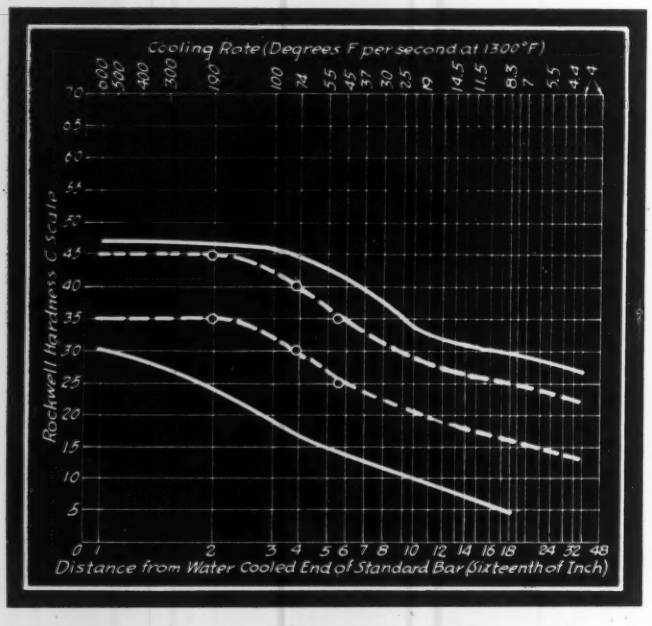


Fig. 22—Broken lines define hardenability requirements of example No. 4 dealt with in article. Solid lines show maximum and minimum hardenability of 35 heats of 4620 steel as revealed in recent SAE-AISI survey

Upper and lower hardenability limits for 35 heats of 4620 are shown in *Fig.* 22. Also shown are the limits for example No. 4 which are considerably narrower than the normal spread for 4620 steel. Such a hardness spread could not be tolerated. Therefore, the metallurgist must either vary the heat treatment to suit the hardenability of each heat of steel, or heats that have hardenability outside the desired limits must be diverted to other applications having requirements more in keeping with the hardenability of those heats. Some manufacturers prefer this course because it results in a product having more uniform properties since more uniform treating temperatures can be maintained. Such a procedure necessitates a hardenability determination on the steel before it is rolled into billets so that the proper size rolling can be selected, depending upon the hardenability. The customer makes arrangements with the steel producer to use the heats having high hardenability on articles of heavier section size and those heats with low hardenability on articles having lighter section size.

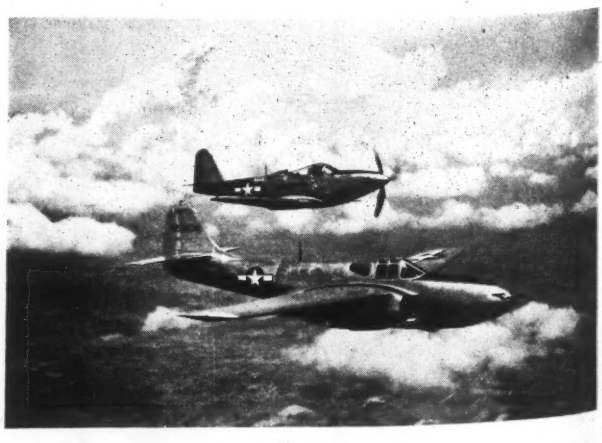
Our First Jet-Propelled Plane

WHILE military security still cloaks in secrecy many details of the nation's first jet-propelled plane, there are some facts which the War Department has brought into the open. Designed and built by Bell Aircraft Corporation of Buffalo, this plane is extremely fast, already having been rated at well over 400 miles per hour. Known as the P-59 Airacomet, it weighs about five tons, has a slender fuselage, a long upswept tail and a wing span of 49 feet.

In appearance the jet plane resembles any mid-wing fighter, the chief distinction being the absence of a propeller. It has an extended nose, tricycle landing gear and employs the "laminar-flow" type of wing.

At the front of each jet engine is an air intake duct. Rotary compressors, which are actually high speed fans, suck up the air and force huge quantities of it under pressure into a combustion chamber. The air is mixed with kerosene and the combustion causes expansion at constant pressure. This pressure forces the gases through a turbine—another fan-like wheel—which supplies the power to drive the compressors.

An external source of electrical power generally is used to start the engines. The jet is smooth, producing a continuous stream of gases. The engines set up but little vibration, so little in fact that it was found necessary to install a vibrator on the cockpit panel to insure elimination of stickiness from the needles of the instruments.



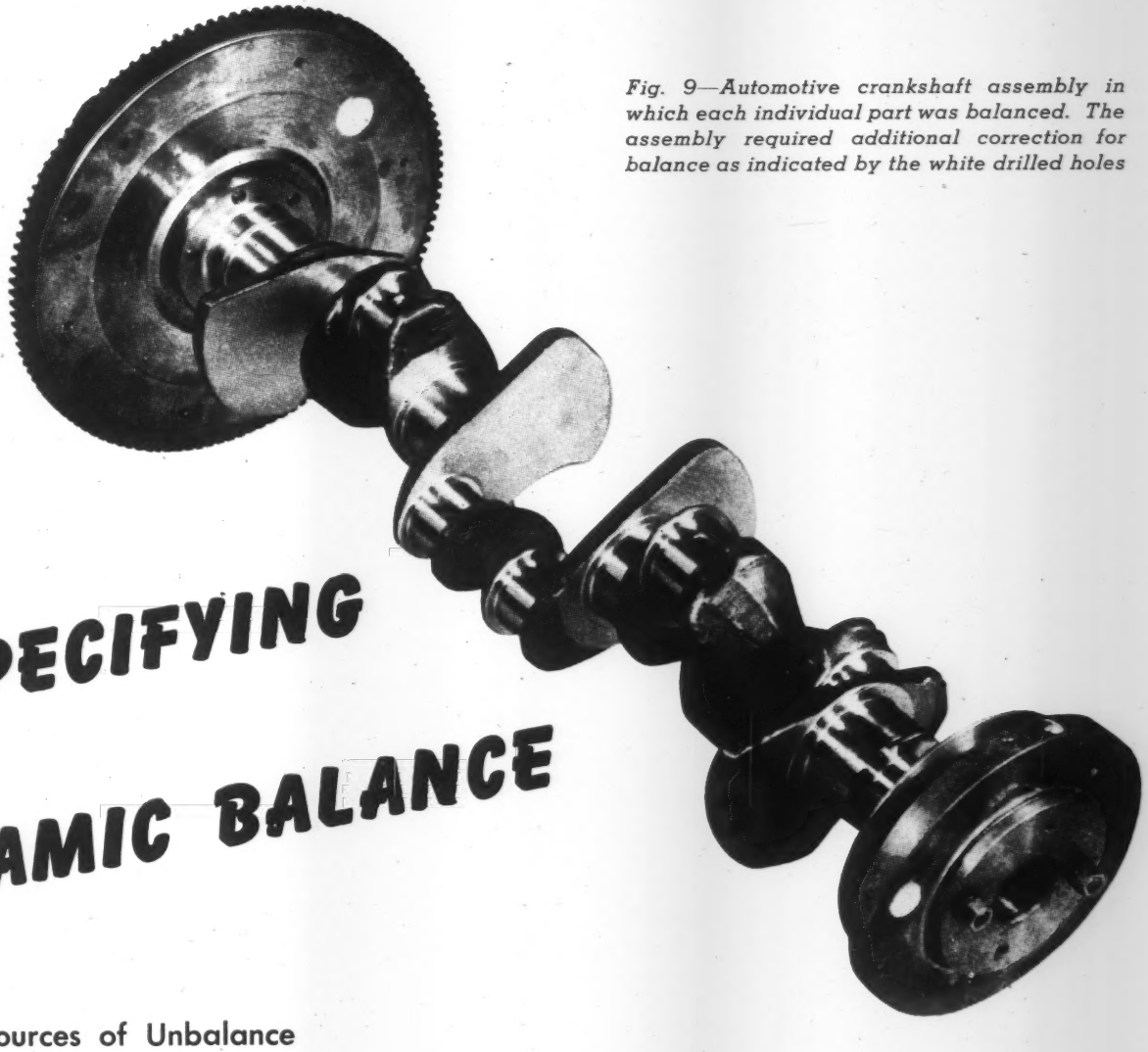


Fig. 9—Automotive crankshaft assembly in which each individual part was balanced. The assembly required additional correction for balance as indicated by the white drilled holes

SPECIFYING DYNAMIC BALANCE

Part II—Sources of Unbalance

By W. I. Senger

Balancing Machine Division
Gisholt Machine Co.

IN THE discussion thus far, it has been assumed that unbalance was produced by a number of eccentrically mounted disks. One may well ask, "How can there be unbalance in a perfect cylinder made of good steel and accurately ground?" Microscopic or X-ray examination would show that there is definitely a difference in density of parts between various sections. This difference can easily cause the actual center of gravity to be eccentric with respect to the rotational axis. Naturally, this is more pronounced in cast metal; but it always is a source of unbalance.

If a hole were bored through the rotational axis of this perfect cylinder, and if it were mounted on a perfect arbor, one might think that the only unbalance which could possibly be present would be the unbalance due to differences in density of different parts of the cylinder. However, in boring the hole through the cylinder, some tolerance must be permitted as regards eccentricity between the bore and the outside diameter of the cylinder. Even though the cylinder were ground on its outside diameter from a good arbor mounted in the bore, the arbor itself must necessarily have some run-out even though it be of the order of .0001 inch. Even this small arbor run-out must necessarily throw the entire mass of the cylinder off center and thereby introduce unbalance effect. Thus manufacturing tolerances contribute to errors in balance.

Further, assuming that the hole bored in the cylinder has a diameter of 1.0000 to 1.0005 inches, and that the shaft on which the cylinder is ultimately mounted has a diameter of .9995 to .9990-inch in order to make production possible, even though the center of gravity of the cylinder is on

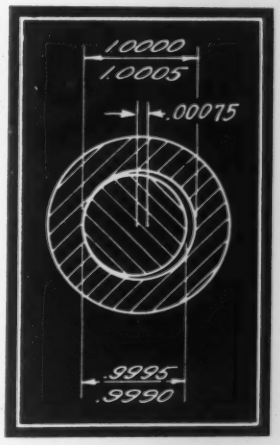


Fig. 10—Left—Mounting a high-limit tolerance hub on a low-limit shaft may displace the center of gravity of the assembly

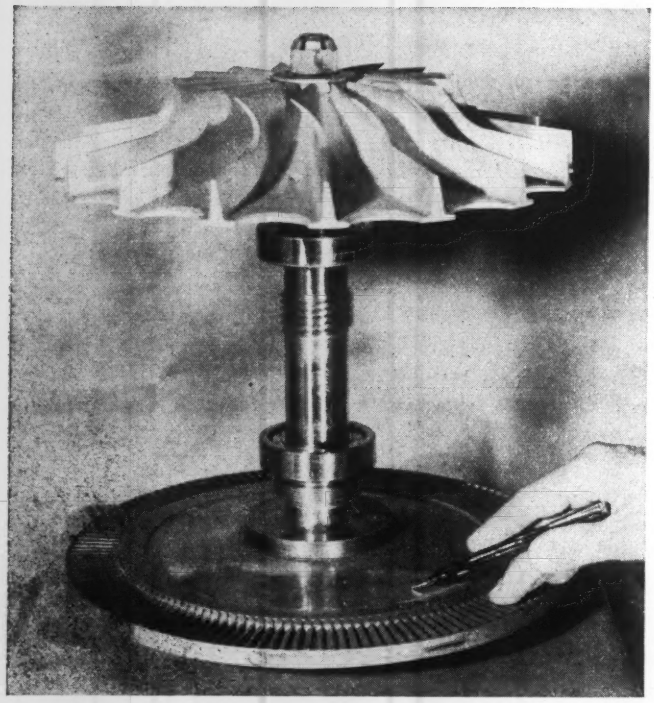


Fig. 11—To eliminate vibration effects which might be produced by eccentricities of the bearing inner races, this turbine-driven supercharger is balanced on its bearings

the center of the bored hole, it should be evident that, in mounting a high-limit cylinder on a low-limit shaft, it is possible to have the center of gravity of the cylinder displaced from the shaft axis by as much as .00075 inch, as shown in *Fig.* 10. Now, if the cylinder weighs 60 pounds, or 960 ounces, this possible eccentricity (from Equation for static unbalance in Part 1) will make possible an unbalance effect of 960 × .00075, or .72 ounce-inches. This unbalance error would be present even though the cylinder itself were perfectly in balance about the center line of its bore. It would, therefore, appear reasonable to assume that the tolerances for balance should be made only after due consideration has been given to manufacturing tolerances and the construction of the piece itself.

Balancing Parts on Own Bearings

An unbalance effect similar to that already discussed will be produced in parts which are balanced perfectly on the shaft diameters on which ball bearings are to be mounted; for, after mounting the ball bearings, which inevitably have some eccentricity in the inner race, it is obvious that the rotational axis of the work piece will be displaced by an amount equal to one-half of the run-out of the inner race of the ball bearing. Therefore, in considering the balancing of any body supported on ball bearings as in *Fig.* 11, it is well to consider that the body should be balanced on its own ball bearings in order to obtain a maximum reduction in vibration due to unbalance effect.

Often it is found that there is necessity for the replacement of these bearings; and if such is the case, the balancing tolerances will have to be set rather high, and the balancing will have to be done on the shaft diameters on which the ball bearings fit. However, the vibrations due to unbalance effects brought about by the eccentricity of the inner races of the bearings must then be accepted as being entirely out of the control of the manufacturing division.

It may be well to note that ball bearings may produce vibration effects from sources other than run-out of the inner race of the bearing, *Fig.* 12. Out-of-roundness of the balls, out-of-roundness of the outer race due to mounting in a hole which is not round, poor ball retainers, or

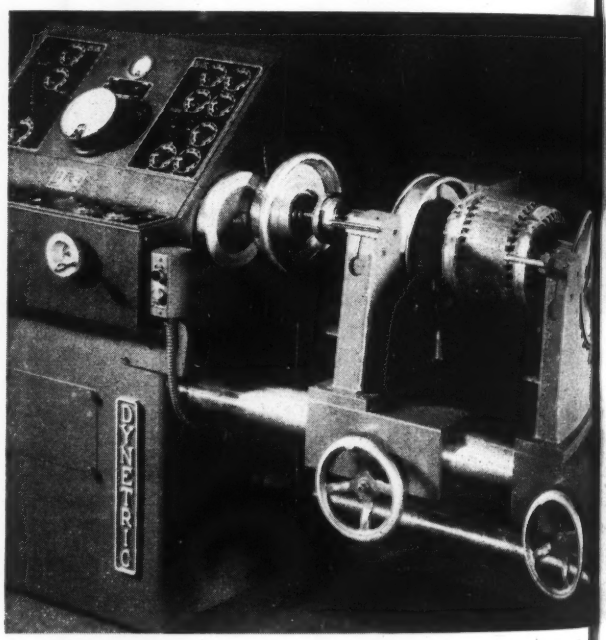


Fig. 12—Direct-current motor armature being balanced on cartridges which carry the ball bearings

dirty bearings all will cause vibrations of a shaft carried by a bearing having any of these features. If parts are to be balanced on their own ball bearings, the bearings used should be clean and should meet the grades established as ABEC4 or ABEC5 by the Annular Bearing Engineer's Council.

The roundness to which a shaft or bearing portions of

Unbalance Introduced by Adding Balanced Parts to Balanced Assemblies

(unbalance in ounce-inches)

Crankshaft Assembly No.	Plane of Unbalance	Unbalance in Crankshaft only	Unbalance in Assembly of Crankshaft and Flywheel	Unbalance Due to Clutch when Mounted on Balanced Assembly of Crank and Flywheel	Unbalance Due to Belt Pulley when Mounted on Balanced Assembly of Crank, Flywheel, Clutch	Unbalance in Complete Assembly of Balanced Parts
1	a_1	.355 @ 274°	.157 @ 17°	.720 @ 133°	2.014 @ 185°	1.425 @ 185°
	a_2	.260 @ 188°	.833 @ 330°	2.162 @ 315°	.594 @ 346°	2.109 @ 308°
2	a_1	.262 @ 254°	.365 @ 100°	1.790 @ 249°	1.90 @ 26°	1.04 @ 175°
	a_2	.729 @ 229°	1.643 @ 350°	4.66 @ 68°	.515 @ 220°	2.70 @ 137°

a rotating body are ground also contributes to the accuracy to which it is possible to balance. This may be observed by reference to *Fig.* 13 in which the rotation of the shaft is indicated by the curved arrow, and the center of gravity of the rotating body is at *A*. When the contacting point *B* on the shaft moves over to contact with point *C* of the bearing, it is obvious that the center of gravity of the shaft must move in the direction indicated by the arrow *D*. This motion will give a vibration at the same frequency as that produced by unbalance, but it cannot be compensated for by a balancing correction. Obviously the remedy for such a situation is to grind the shafts absolutely round because any deviation from roundness will introduce vibration effects which have the appearance of being due to unbalance.

From time to time, armatures of electric motors with wound rotors, *Fig.* 14, produce vibrations caused by unbalance. These vibrations are often due to the shifting of coils in the armature as the speed of the armature

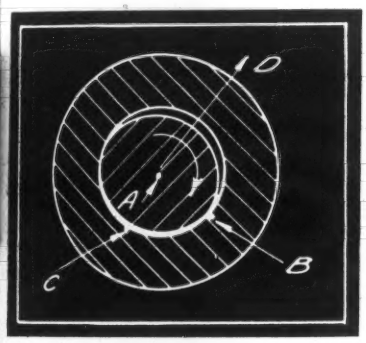


Fig. 13 — Sketch showing how vibration may result from shifting of center of gravity in bearing

changes. Obviously it is not possible to dynamically balance parts unless all increments of mass in the body stay at the same radius at all speeds of rotation. If such rotors have a single operating speed, balancing at that operating speed will, of course, take care of any displacement of coils for that speed. However, if at any time the motor is run at other speeds, then the vibrations due to coil shift will necessarily occur.

Warped Shafts Cause Unbalance

A rotor in which the shaft ends are bent or warped is represented in *Fig.* 15. Such a condition can easily be obtained by pressing a cylinder on to a ground shaft. The operation of pressing the cylinder on to the shaft will cause cold working of the shaft, which in turn causes the shaft to bend. Where such conditions can possibly exist, it is desirable to grind the shaft after the cylinder has been pressed on to the shaft. From the drawing it is obvious that the rotational axis of the body cannot be determined if it has a bent shaft because the actual bearing surfaces determined by the supporting bearing are continually changing. This continuous change of bearing surface causes a continuous change of supporting point and of rotational axis, thereby producing an effect similar to that produced by unbalance.

Vibrations due to unbalance are frequently observed in assemblies of parts in which each individual part has been balanced to a high order of accuracy. *Fig.* 16 is an exaggerated sketch to show the several features which may make for large vibrations due to unbalance in an assembly of parts, each of which have been balanced to a high order of accuracy. Cylinder *A* may be balanced dynamically by applying corrections in planes a_1 and a_2 until the remaining unbalance is such as will cause motion of bearings B_1 and B_2 of the order of .00005-inch. Member *C*, which is essentially a disk, may be balanced statically to an accuracy of corresponding order. Now, if the portion of cylinder *A* on which *C* is mounted is eccentric with respect to bearings B_1 and B_2, the balanced part *C* will introduce an unbalance in the assembly represented by the weight of *C* multiplied by the eccentricity. To this unbalance must be added the possibility of the small unbalance remaining in *C* being in the same direction as in part *A*. To this sum must be added the possible unbalance effects due to play between *C* and *A* which will permit a further shift of the mass center of *C* from the rotational axis as determined by B_1 and B_2.

Unbalance Resulting from Assembled Parts

Further unbalance effects will be introduced in the assembly if the face against which *C* locates is not perpendicular to the rotational axis. This will introduce a "wobble" in *C* which makes for dynamic or moment un-

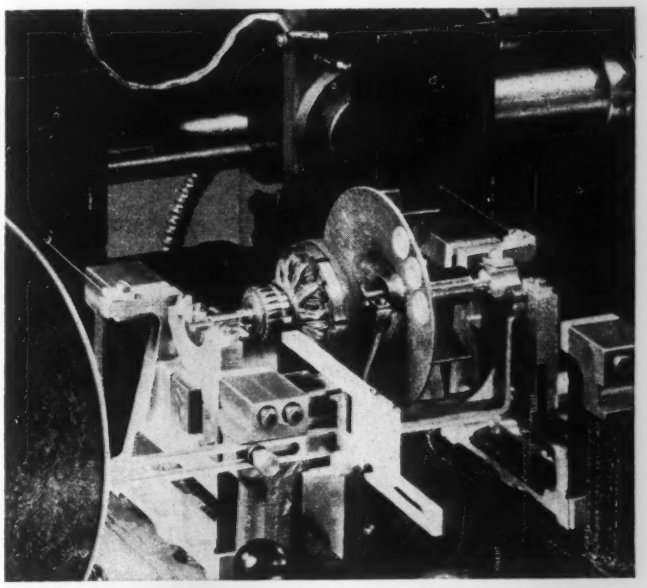
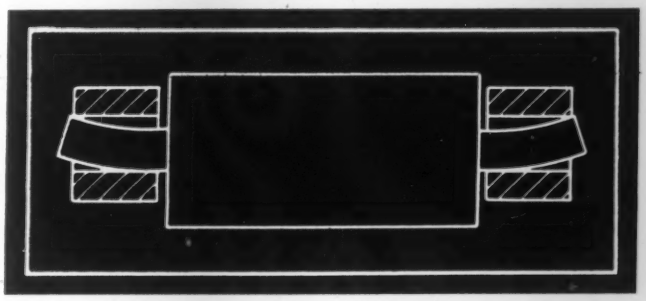


Fig. 14—Above—If windings in a motor armature shift as the speed of the armature changes, the armature can be expected to operate satisfactorily only at the one speed for which the assembly is balanced

Fig. 15—Below—Eccentricity caused by pressing cylinder on ground shaft results in unbalance



balance. This can be seen if C is assumed as made of two parts, an upper and lower half as shown in the sketch. When rotated, the upper half will develop a centrifugal force as represented by c_1 and the lower half a force represented by c_2. Forces c_1 and c_2 are equal in magnitude, but due to the inclined mounting of C against A, the forces are not in the same plane, thereby introducing a dynamic or moment unbalance.

Unbalance Effects in Crankshaft

The tabulation on Page 132 records the results of tests on two automotive crankshaft assemblies, *Fig.* 9, consisting of crankshaft, corresponding to part *A* in *Fig.* 16; flywheel, corresponding to part *E;* clutch corresponding to part *D;* and belt pulley and vibration damper corresponding to part *C*. All parts of the assembly were machined in accordance with the best commercial practice. The crankshaft was dynamically balanced to an accuracy of .25 ounce-inch in each of the planes a_1 and a_2. The remaining parts, which are essentially disks, were statically balanced to a corresponding accuracy. The table indicates the unbalances introduced by the individual parts and gives the cumulative effect of the unbalances. As each part was added to the assembly the observed unbalance effects were removed before another part was added to the assembly. The results indicate the desirability of balancing assemblies as such, even though each part of the assembly may be well balanced within prescribed tolerances.

Unbalance effects produced by unmachined surfaces of cast or forged parts obviously contribute greatly to the

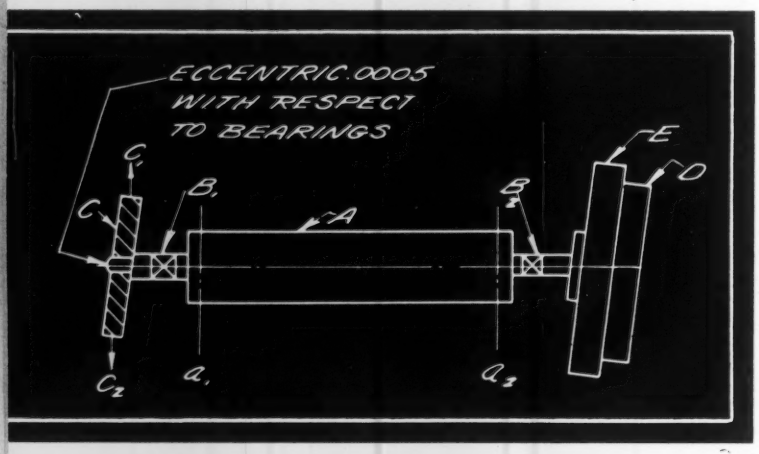


Fig. 16—Representation of unbalance resulting from assembly of balanced parts

amount of unbalance which may be expected in a body. Similar effects are produced by drawing or forming operations and by welding or fabricating.

From the foregoing discussion, it should be evident that the unbalance tolerance established in any rotating body should be a function of the weight of the body, the distribution of mass in the body, the accuracy to which the bearing surfaces and other parts of the body are machined, the rigidity of the body, and the like.

(*Continued in next issue*)

Luxury Airliners Assure U. S. Leadership

COMMERCIAL development of the Douglas four-engine C-54 will produce two types of luxury passenger planes. One, the DC-4 will be a four-mile-a-minute, 44-passenger and cargo transport equipped with 1450-horsepower Pratt and Whitney twin-wasp engines; the other will be the DC-6 a five-mile-a-minute, 56-passenger and cargo liner equipped with 2100-horsepower double-wasps.

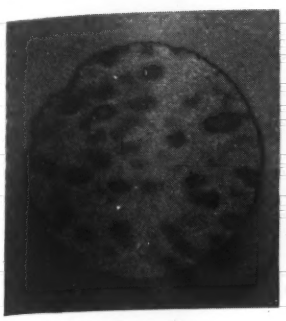
The DC-6 is said to be the fastest transport available either in this country or abroad for the immediate postwar period. Its nonstop cruising range is 2751 miles and the ship can be equipped for increasing this range to 3540 miles. Having a gross take-off weight of 80,500 pounds, it will have a wing span of 117 feet and an overall length of 100 feet. Both the DC-4 and DC-6 will have fully retractable tricycle landing gear, a steerable-type nose wheel and three-bladed hydromatic Hamilton propellers.

Will Reduce Flight Time

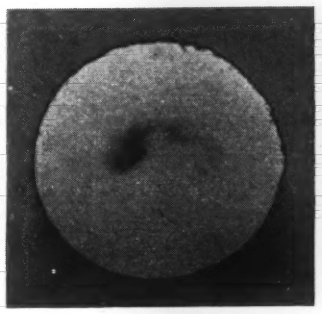
Radical reductions in flight times will be accomplished with these planes. The DC-6 will be able to reduce coast-to-coast scheduled time for passengers, mail and express to approximately eight and one-half hours, Chicago-New York time to two hours and forty minutes.

In addition to their speed, the new superliners will offer modern refinements in passenger appointments, in scientific sound proofing, in meal service facilities and other luxury travel niceties. The DC-6 also will have a pressurized cabin insuring passenger comfort at high altitudes.

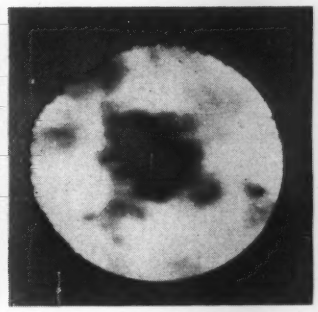
These planes, according to Donald W. Douglas, president of Douglas Aircraft, "definitely assure postwar leadership for the United States in world air transport. With their unrivaled speed, comfort and operating efficiency, these new transports will represent a long stride forward in domestic and international airline service. It is our sincere hope that they also will assist in the reconstruction and rehabilitation of the war-torn nations."



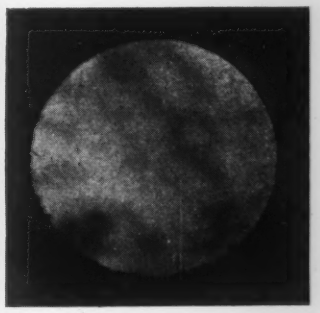
Gas Porosity



Cold Shut



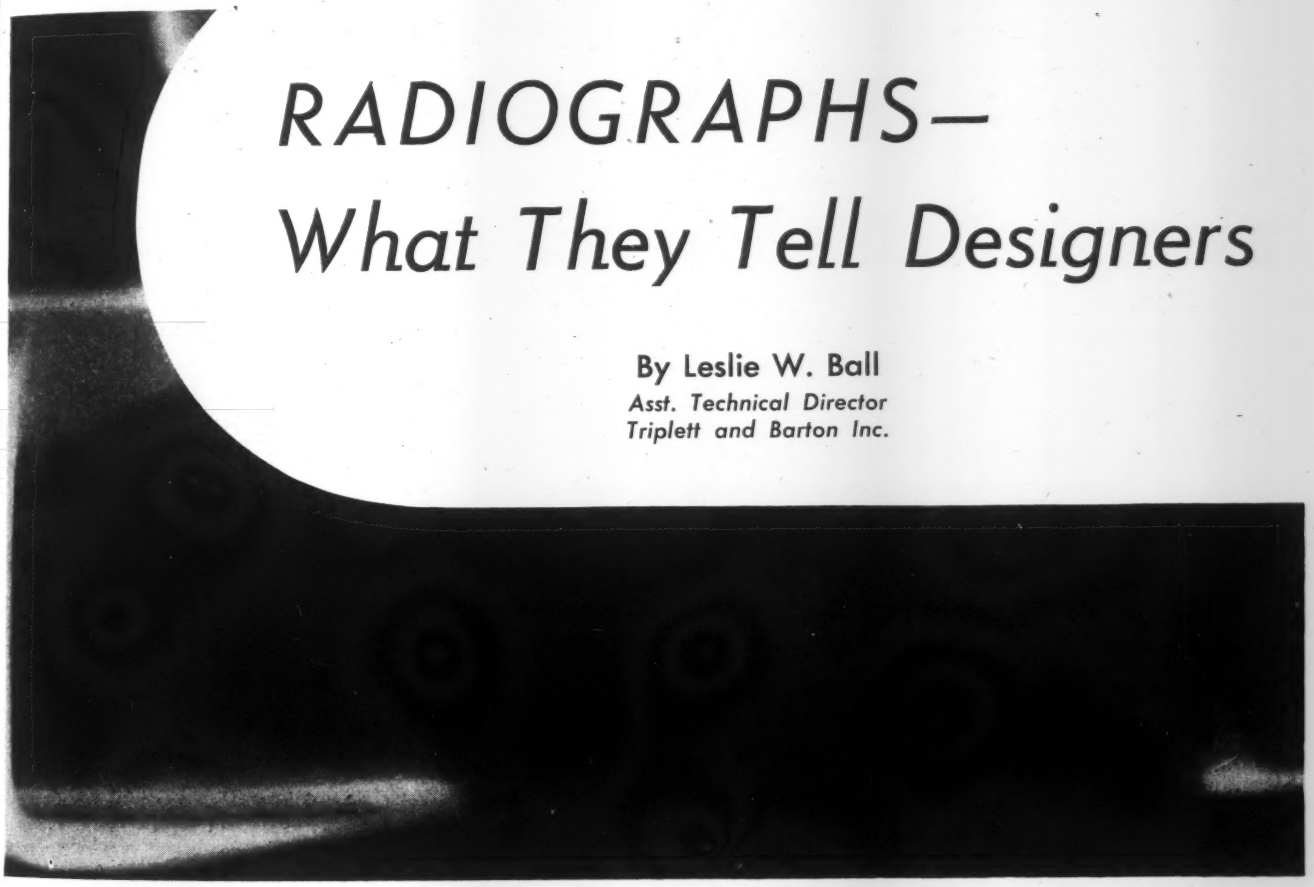
Slag



Microshrinkage

RADIOGRAPHS— What They Tell Designers

By Leslie W. Ball
Asst. Technical Director
Triplett and Barton Inc.



RADIOGRAPHY is used by industry to accomplish specific objectives among which the reduction of service failures and wasted machining costs are predominant. To insure its own future, radiography must achieve these objectives in a more reasonable and economical way than any alternative procedure. Both reasonableness and economy depend on the application of a sound basic procedure and a clear policy of radiographic interpretation.

The X-ray interpreter often is an intermediary between the producer of a raw part and the manufacturer of a finished product. In the case of aircraft, the interpreter is invested by the manufacturer with responsibility for applying quality standards to the acceptance and rejection of raw parts such as castings. The interpreter's standards have to insure that no unserviceable part goes into an airplane, but also he must realize that his decisions can mean the difference between profit and loss to a producer, such as for example, an aluminum foundry. Some disagreement over X-ray rejections is inevitable, but if these rejections are not supported by a clear and consistent policy, disagreement can lead to extravagant condemnation of the whole X-ray function.

Existing published data and standards for radiographic interpretation are extremely meager. In the case of steel castings, the U. S. Navy Standards are excellent, but their application is limited to large parts. In the case of steel welds, the radiographic sections of the Boiler Code are

Fig. 1—Top—Radiographic images produced by secondary radiation. These are not due to defects in material

Fig. 2—Above—How a welding crack looks in a radiograph. This is one of "sharp discontinuity" defects

Abstract of a paper presented at the twenty-sixth annual convention of the American Society for Metals in Cleveland.

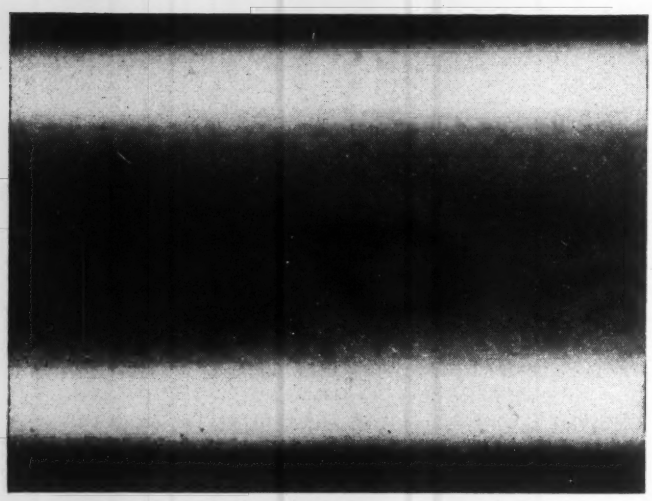


Fig. 3—Cold shut indicated radiographically above is in most cases a defect calling for rejection of the part

useful for a limited class of construction, and the Ordnance Standards are helpful for some other applications. As for the aircraft field, only a few correlations between strength and specific defects have been made and most rejections are still based on unpublished and often confidential experiences. The Air Corps Technical Report No. 4796, was a necessary first step, but its substance merely scratches the surface of the problem. Its static test requirements are welcome and valuable when used as a general guide, but if applied as an absolute criterion of aircraft serviceability, these static load tests would probably lead to service failures under nonstatic loading. Moreover, when defective metal is accepted because an overdesigned part withstands a static test, producers are liable to demand acceptance of defective metal in all aircraft parts. Thus at the present time, the X-ray interpreter cannot rely solely on reference to established standards. His procedure must be based on the application of his own laboratory's knowledge, judgment and testing facilities in fulfilling the objectives for which his radiography is intended.

In the aircraft industry, general requirements for safe and serviceable parts can be broken down into seven specific objectives:

1. Adequate service strength. After being machined and assembled in the airplane, each part must have sufficient strength to withstand continuously the types and degrees of stress for which it was designed
2. Adequate assembly strength. Each part must have sufficient strength to withstand the forces introduced during its assembly into the plane, e. g., riveted sections must be able to withstand the shock of the riveting gun, and attachment brackets must have sufficient ductility to overcome imperfections in seating
3. All parts accepted by X-ray shall pass shop inspections. Each part must be free from cavities that will be revealed by machining, causing the part to be rejected. Shop rejections may be based on:
   a. Unsatisfactory machinability such as a blowhole causing a twist drill to go out of alignment
   b. Stress concentration due to the position of a cavity in the surface
   c. Probable corrosion because a surface cavity will not be sealed by the ordinary anticorrosion treatment
   d. Lack of confidence in the aircraft, caused by reports from the assembly line of the use of defective even though serviceable material
4. Parts subject to hydraulic pressure must be free from any condition which may allow seepage of the hydraulic fluid, e. g., those parts in which the hydraulic seal is formed by a honed surface must be free of even minute cavities in the honed area
5. Parts that are to be assembled by welding must be free of conditions which make welding difficult. They must be free of dross pockets
6. In composite parts which are X-rayed to determine the position of concealed sections, even sound material is acceptable only when required tolerances are attained
7. Some conditions seen on radiographs may lead to corrosion followed by stress failure even though at the time the radiograph is made the part has ample strength. This occurs in several alloys.

Fig. 4—Hot tears, assessed as stress raisers, cause part rejection because they propagate through sections

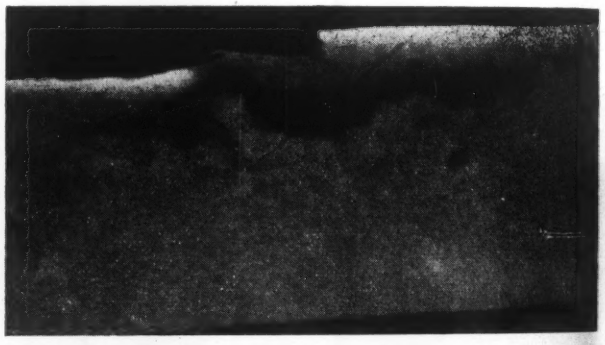


Fig. 5—Radiograph of a surface gap identified as a sand fall in most cases indicates that part should be rejected

The degree of defectiveness that justifies rejection because of one or more of these seven considerations varies from part to part. It varies also with the location of the defect in the part and depends on the design factors and shop inspection standards of the consuming aircraft company.

Amid this complexity, the radiographic interpreter can draw on two fairly simple conceptions. One of these is "commercially perfect metal". A commercially perfect casting is one which can be produced consistently by a

good foundry working with adequate controls and a well designed pattern. A commercially perfect casting is of course free from major defects such as shrink cavities but may contain a few minor imperfections. Even for aircraft use the interpreter can accept without hesitation any casting of this standard. But when radiography reveals a lower quality, acceptance must be based on definite knowledge of limitations in the service requirements.

When the interpreter has no knowledge of limitations in service requirements, he must presume that the casting is a "normal structural aircraft part". This hypothetical part is subject to all types of stress including tension, torsion, shock and fatigue, and also corrosion. However, when the interpreter has a blueprint or other written data which shows limitations, he can adjust his rejection standard accordingly.

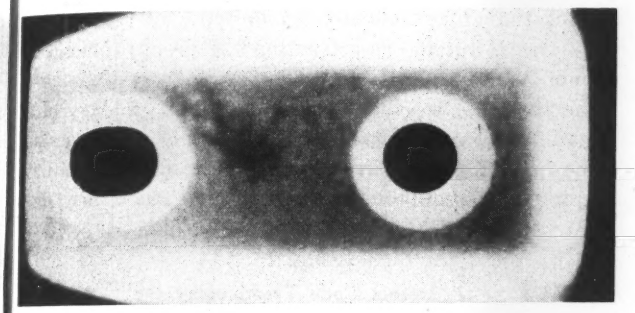
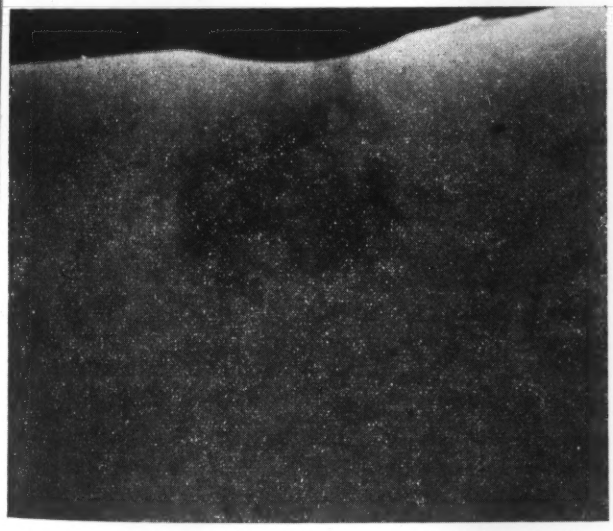


Fig. 6—Above—Shrink cavity is defect readily identified in radiograph. It is indication of bad foundry practice

Fig. 7—Below—Sponge shrinkage appears in radiograph as an area corresponding to a volume of imperfect metal



Few parts are loaded uniformly, so the interpreter must determine from the blueprint where stress concentrations occur. If he is unable to do so he must presume the most unfavorable stress distribution. Obviously, the more information that the aircraft manufacturer provides for the radiographic interpreter, the less will be the rejections.

Perhaps the most vital "ignorance factor" which leads to unnecessary rejections is the ratio of the actual strength of a defective part to the service load. If this ratio is high, the interpreter may accept relatively poor quality material, but if it is low, even slightly defective material must be rejected. Unfortunately this ratio of actual strength to service load can seldom be determined satisfactorily. Theoretical design calculations involve wide approximations and the jigs used for static tests seldom reproduce the actual service stresses.

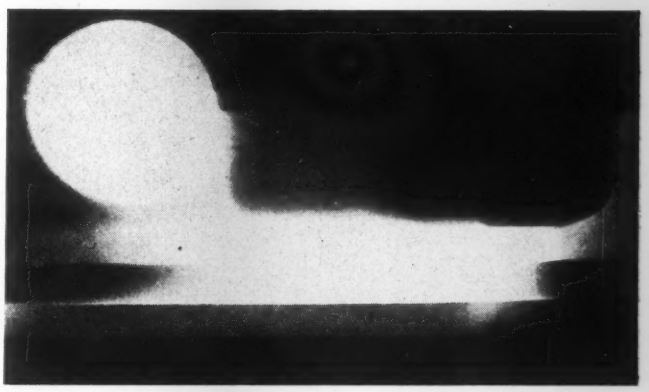


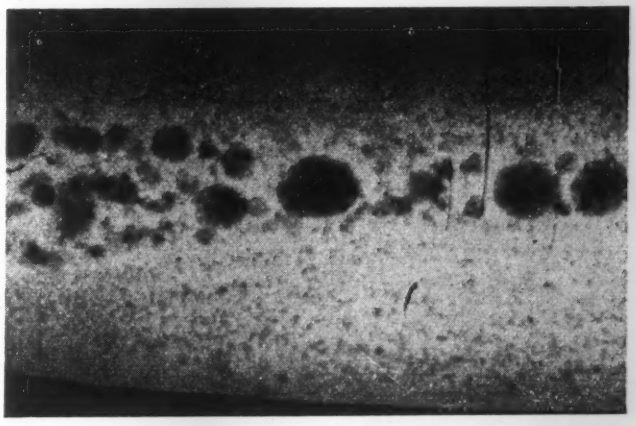
Fig. 8—Shrink pipe, like "cavity" and "centerline", is defect which appears in radiograph as discrete image

Because of these limitations in determining this ratio, aircraft designers with whom we work are unwilling to accept defective material even when it cannot be proved that the defective part will fail in service. On the other hand, foundries are unwilling to scrap large quantities of defective but apparently serviceable parts.

Compromising these attitudes is a job that has to be faced by the radiographic interpreter. His decisions are guided by the function of the part as well as by the loading factors. Any part whose failure would cause disaster to a plane should be subject to 100 per cent X-ray inspection and the interpreter should accept only commercially perfect material. Of course the interpreter must realize that a part which is difficult to make will carry a slightly lower standard than one of more simple design. About one quarter of the total number of cast parts in a plane are of the 100 per cent X-ray class.

Rejection of parts whose failure will not cause disaster should be based on a rough calculation of the reduction in the physical strength of the part. To make this calculation the interpreter must be able to do three things: First, he must have enough knowledge of engineering to visualize possible modes of failure. Second, he must have enough knowledge of radiographic metallurgy to identify

Fig. 9—Shrink centerline, along with other defects of "shrinkage" type, may or may not cause part rejection



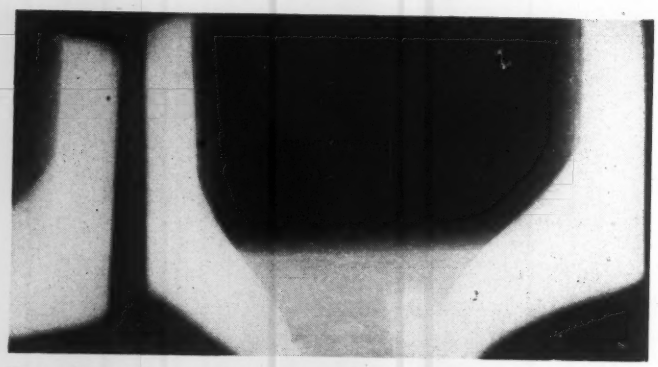


Fig. 10—Above—Radiographic appearance of defect termed "gas holes" corresponds to discrete voids of clearly visible size. Holes are spheroidal and smooth walled

Fig. 11—Below—How pin holes look to the radiographer. Holes are small spheroidal voids occurring in groups

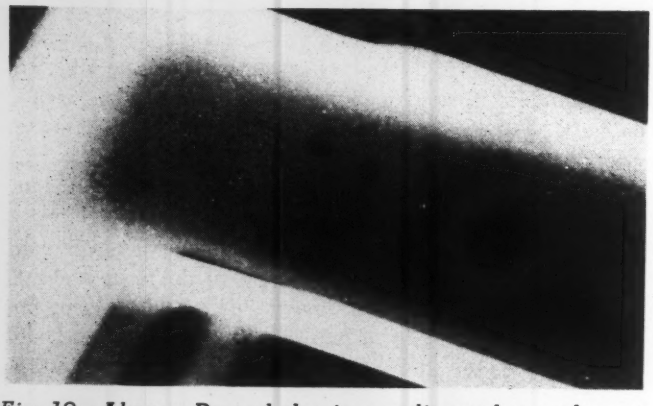
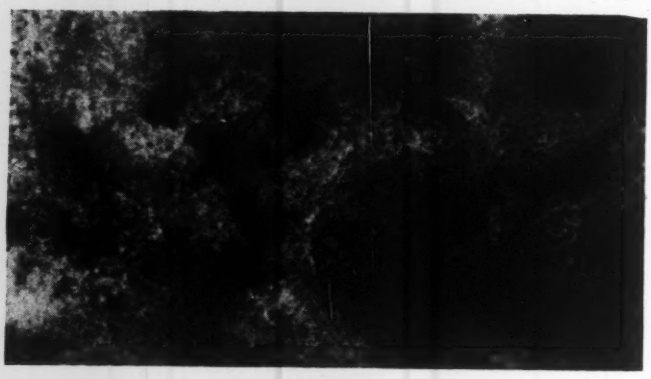


Fig. 12—Above—Dross holes in a radiograph are characterized by their irregular shape and distribution

Fig. 13—Below—X-ray micrograph of gas porosity, one of the dispersed defects prevalent in light-alloy castings



the defective condition. Third, he must have data such that decrease in strength can be deduced from radiographic appearance.

Before dealing with identification and assessment of genuine defects, it should be noted that there are many radiographic appearances which are not due to defects in the material. For example, *Fig.* 1 shows four types of image produced by secondary radiation. Training in the recognition of the various types of false images is a prerequisite for all radiographic interpretation.

To deal with identification and strength assessment in an orderly manner we have found it convenient to use six groups of defects. TABLE I shows this grouping. The titles of the groups correspond to types of radiographic appearances, but the terms within the groups conform to common metallurgical usage.

The first title is "sharp discontinuities". Radiographic appearance of each of the defects in this group consists of one or more dark narrow lines. One advantage of this grouping is that although different interpreters may dis-

TABLE I

Defect Code Terminology

GROUP 1	GROUP 2	GROUP 3
Sharp Discontinuity	**Shrinkage**	**Holes**
1.1 Crack*	2.1 Cavity	3.1 Gas*
1.2 Cold shut: Lap, Fold	2.2 Sponge	3.2 Pin*
1.3 Hot Tear	2.3 Pipe	3.3 Dross*
1.4 Surface*	2.4 Centerline	3.4 Surface*
GROUP 4	**GROUP 5**	**GROUP 6**
Dispersed Defects	**Heterogeneities**	**Welding (Also*)**
4.1 Gas Porosity*	5.1 Light Inclusions*	6.1 Incomplete Fusion
4.2 Shrink Porosity	5.2 Heavy Inclusions*	6.2 Undercut
4.3 Microshrinkage	5.3 Segregation	6.3 Draw
4.4 Microtears	5.4 Stress Segregation	6.4 Linear Porosity

*All defects carrying asterisk (*) may occur in welding.

agree on the exact identification of a defect, they will agree on its general radiographic appearance and so will assign it to the same group.

Standardization Made Possible

Another advantage is that the same sort of strength tests and acceptance standards applies to the defects within each group. In Group 1 sharp discontinuities are assessed as stress raisers. They almost always are rejectable, because they will propagate through the section. The defects in Group 1 are illustrated by *Figs.* 2 to 5. *Fig.* 2 shows a crack; *Fig.* 3, a cold shut; *Fig.* 4, a hot tear, and *Fig.* 5, a surface gap. These four sharp discontinuities are cause for rejection in all classes of castings, forgings, and extrusions. Only occasionally is one of these defects so orientated that it is acceptable.

The second group of defects is entitled, "shrinkage". Radiographic appearances of shrinkage are related to each other by their position in the casting. Variations in shape and pattern of shrinkage images depend on the alloy, method of fabrication and geometry of the individual part. However, after suitable training the interpreter is able to identify shrinkage with fair certainty. *Figs.* 6 to 9 illustrate the subdivision of "shrinkage" into four individual types. *Fig.* 6 shows "cavity"; *Fig.* 7, "sponge"; *Fig.* 8, "pipe"; and *Fig.* 9, "centerline". Three of these, the cavity, pipe, and centerline, appear in the form of discrete images that can be identified easily. Since they represent bad foundry practice they are just

cause for rejection in the 100 per cent X-ray class of casting. However, these defects also occur in forms so slight that they are acceptable in other classes of casting.

By contrast, "sponge shrinkage" does not appear as a discrete defect, but as an area on the radiograph corresponding to a volume of imperfect metal. Although honeycombed with tiny voids the metal may have considerable strength. Without a background of investigation, the radiographer cannot tell either the extent of the sponge in the direction of the X-rays or the strength of the affected region.

Test Pieces Aid Interpretation

In our laboratories we have sought to provide this background in two steps. The first was the making and radiographing of slices through selected sponge sections. This procedure showed both the extent of the sponge and the degree of honeycombing. Thus, the interpreter is guided by comparing the contrast and general appearance of radiographs with these test cases. The second step is to estimate the strength and corrosion resistance of the different types of sponge. In general the coarser the honeycomb the weaker the metal, but no adequate series of test-bar measurements are available.

The third group of defects is entitled, "holes". Their radiographic appearances correspond to discrete voids of easily visible size whose width, breadth and depth are roughly equal. *Fig.* 10 shows "gas holes". These are smooth-walled, spheroidal and occur individually. *Fig.* 11 shows "pin holes" (or cluster porosity), a condition distinguished by the occurrence of small spheroidal voids in a group. *Fig.* 12 shows "dross holes", characterized by their irregular shape and distribution. Surface holes occur as an innumerable variety of sand failures, etc., and their appearances are correspondingly varied.

TABLE II

Rating Code Terminology

Normally Acceptable		Normally Not Acceptable	
—1—	Trace	—5—	Excessive
—2—	Some	—6—	Heavy
—3—	Appreciable	—7—	Extra Heavy
—4—	Considerable	—8—	Extreme
—Q—	Questionable (insufficient engr. data to grade)	—9—	

Note: The Interpretation Code consists of the View Number and a Rating followed by the Group and then the Type of defect. For example, 1—4—4.1 means View 1 has a Rating of 4 on a dispersed Type of defect identified as Gas Porosity.

It is not possible to establish universal standards for holes of any type, particularly in an aircraft casting. Rejections must be based first on the feasibility that a fracture of the part could pass through the holes and secondly on the size, shape, orientation, and distribution of the holes relative to the fracture surface.

Majority of rejections due to holes are based on machine shop standards. This means that the interpreter has to predict if the hole will be revealed by machining. Another consideration is that holes—particularly dross holes—are evidence of turbulent pouring or poor mold design. When the interpreter considers these deduced metallurgical factors are unsatisfactory he should reject the parts. To guide our interpreters' rejection standards, we have among our reference films several dozen cases

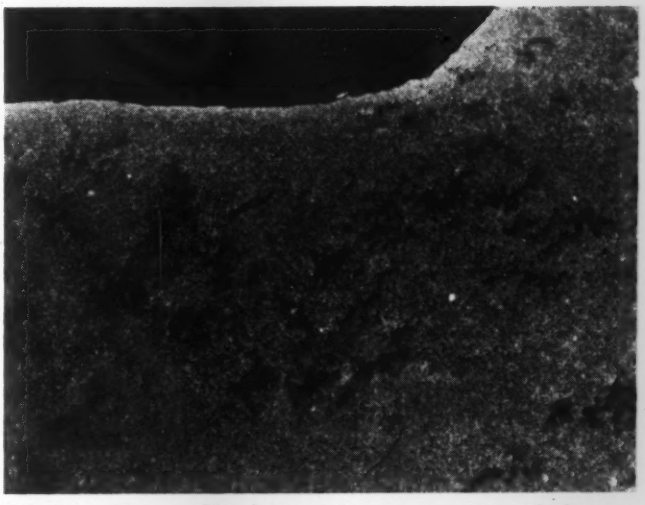
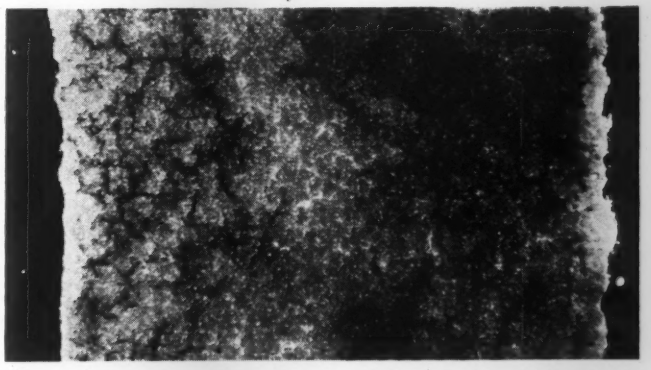


Fig. 14—Above—Chief cause for many casting failures is "shrink porosity" shown in this X-ray micrograph

Fig. 15—Below—Appearance of magnesium microshrinkage in X-ray micrograph. This is one of "dispersed defects"



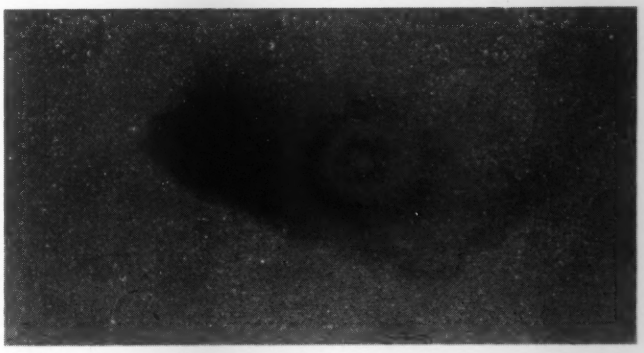


Fig. 16—Above—Radiograph of a light inclusion. This is one of defects in group identified as "heterogeneities"

Fig. 17—Below—Radiographer's identification of "heavy inclusion" is based on knowledge of metallurgy of part

where holes have been carefully assessed. Satisfactory judgment can be acquired by an interpreter through studying these reference films.

The fourth group of defects may be called "dispersed defects". They consist of metallurgical conditions in which tiny voids are scattered throughout part or all of a casting. They are particularly prevalent in light alloy castings. Dispersed defects on radiographs give rise to a wide range of appearances such as mottling, dark streaks, speckles or extremely small tears. With sections of metal more than ½-inch thick, it rarely is possible to distinguish

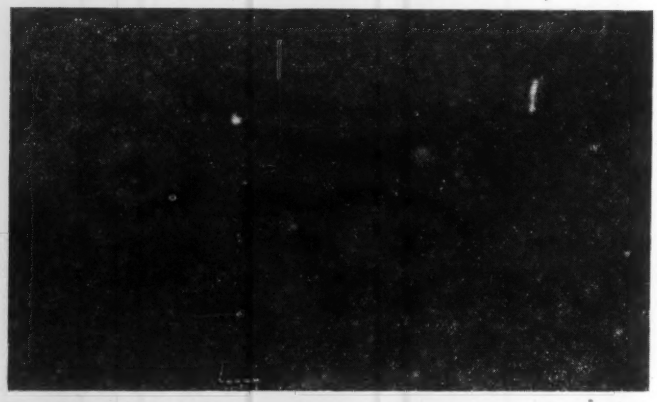
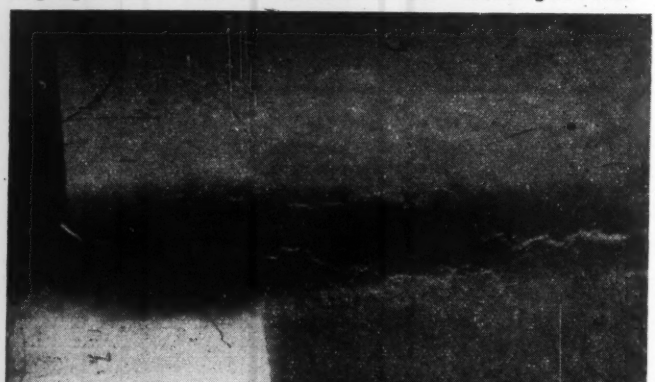


Fig. 18—Above—Segregation as it appears to the radiographer. General type demands few casting rejections

Fig. 19—Below—Radiograph of the defect known as stress segregation. This is another of the "heterogeneities"



many discrete images corresponding to the individual voids. However, radiographs of slices of metal about twenty thousandths of an inch thick do show the presence of individual voids.

To enable our radiographic interpreters to identify each of the four subdivisions of dispersed defects, we have prepared enlargements, from 2 to 200 diameters, of radiographs of slices of aluminum and magnesium alloys. Our library of reference films correlates the appearance of the nondestructive radiograph with the sliced X-ray micrograph. X-ray micrographs of gas porosity, shrink porosity and magnesium microshrinkage are shown in *Figs.* 13, 14 and 15 respectively.

Assessment of the acceptability of material containing dispersed defects should be based on an extensive series of correlations between radiographic appearance and physical characteristics of test coupons. Tests on complete castings are a useful supplement but rarely provid fatigue, shock or elongation data. Moreover, by th method it is impossible to investigate the scores of vari tions that occur in the shape, size and orientation microcavities.

The deleterious effect of shrink porosity depends grea ly on the dimensions of the section in which it occur Perhaps the greatest pitfall in the radiographic interpret tion of aircraft parts is the failure to reject castings co taining shrink porosity in sections which are cast thic but machined thin. For example, in a certain engi cowl-bracket the cast section is 1-inch thick but th flanges left by machining are only ⅛-inch thick. Th same shrink porosity that reduces the strength of the ori inal section by 10 per cent can reduce the service streng by 75 per cent. The majority of casting assembly failur that occur in aircraft production are due to reduced du tility caused by shrink porosity.

The fifth group of defects is "heterogeneities". Thes appear on the film as variations in film blackening n corresponding to variations in thickness or to the presen of cavities or scatter. They are due to nonuniformity composition or density of the material.

Metallurgical Knowledge Required

Both light and heavy inclusions are well understoo Their identification by the radiographic interpreter based on a knowledge of the metallurgy of the produ being examined. A light inclusion in steel may be iden fied as a sand pocket, but in aluminum it would mo probably be a dross pocket. In our laboratory interprete acquire satisfactory judgment of this type of defe through studying a library of carefully analyzed film Rejectability of inclusions is based on considerations sim ilar to those described under "holes". The standards a rather more severe where corrosion or damage to a ma chine tool is possible.

General segregation seldom is cause for rejection i castings but, in forgings and extrusions, excessive stri tions on the radiograph in the direction of the flow line are associated with cracks and may cause rejection. *Fig* 16 to 19 show the four types of heterogeneity.

In Group 6 the defects peculiar to steel welding a listed. In the case of magnesium welding there are few causes for rejection which do not occur in steel.

This completes the list of defects. The assignment o code numbers of 1 through 6 to the groups, and numbe of 0.1 through 0.4 to the items in the groups is invaluabl both in writing reports and in making statistical analyse This need for coding on X-ray reports is important in th aircraft industry. The addition of a "degree of rating code, of 1 through 8, allows the summarizing of all th conditions in more than a hundred defective castings o a single page. TABLE II shows a rating code that ha proved to be satisfactory.

Future use of radiography is dependent on it providi a more reasonable and economical method of performi certain tasks than any alternative. The reasonableness conclusions based on radiography is very much in th hands of the interpreters. Thus, development of profe sional status and recognition for them is of vital impo tance.

Vibration and Noise—

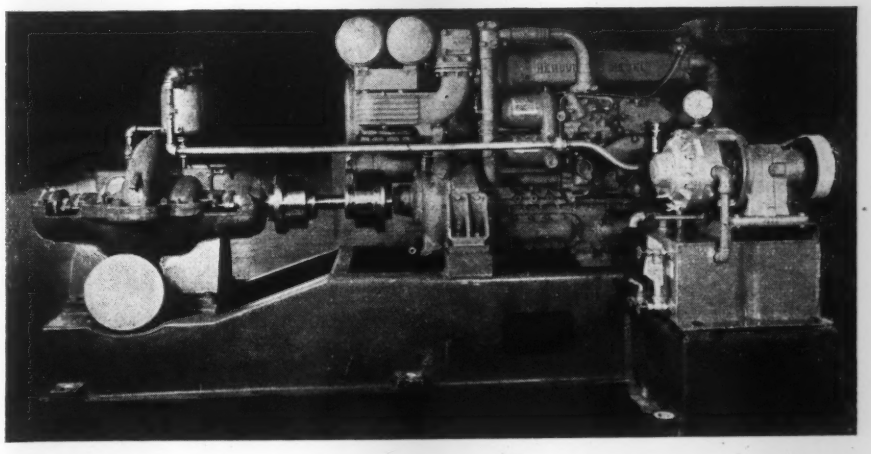


Fig. 46 — Torsional vibration trouble leading to possible fracture of the shaft was averted in this engine-driven pump through use of a double resilient coupling

Causes and Cures

By Colin Carmichael

Part V—Torsional Vibration

TORSIONAL vibration, which is simply the variation in twist experienced by a shaft when transmitting a variable torque, is present in greater or less degree in practically every type of drive. In general, it becomes serious only when the frequency of the applied torque variation is close to the natural frequency of torsional oscillation for the system of rotating parts constituting the drive. Although the literature on torsional vibration deals mostly with engine drives, such as shown in *Fig.* 46, because that is where the severity is greatest, many other types of machines also are susceptible to trouble from this source. It is the purpose of this article to present, in as simple a manner as possible and without mathematical derivations, the basic equations and methods for predicting critical speeds at which trouble may be expected, as well as a discussion of the principal cures available. For detailed discussion of specific problems such as those encountered in multicylinder engines, the reader is referred to the textbooks and papers listed at the end of the article.

Torsional vibration is not directly visible or perceptible as such because it is superimposed on a steady rotation, and the resulting variations in instantaneous speed of any part of the shaft usually are only a small percentage of the average speed. Sometimes dangerous torsional vibrations go unsuspected until fatigue failure occurs in the shaft or in the gear teeth or other part of the drive. In some cases the energy of the torsional vibration may be transformed into other forms of vibration, causing various parts of the machine to vibrate or rattle. Inasmuch as these manifestations are not themselves torsional the problem often is an elusive one.

Avoiding Critical Speeds

Objectives of torsional vibration analysis are: (1) Calculation of natural frequencies and critical speeds and (2) calculation of vibration amplitudes and stresses. The first group of calculations should be standard procedure for any system of rotating parts where two or more relatively heavy masses are connected by shafting, and will be explained in this article. Should the results indicate possible trouble, the necessary remedies are then applied and the calculations repeated until satisfactory freedom from dangerous or objectionable vibration is indicated.

Whether or not it will be necessary to perform the second group of calculations depends upon the outcome of the first. However, calculation of vibration amplitudes and stresses is beyond the scope of the present article. There are too many different ways of combining a number of rotating elements, and too many places at which the disturbing torque variations which are responsible for inducing vibration could be applied, to permit of a general solution. Also, the factors affecting damping are difficult to evaluate. Accordingly each case must

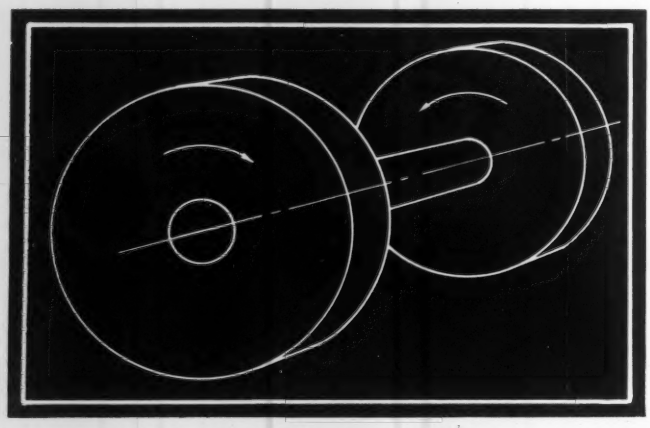


Fig. 47—In two-mass torsional system two disks can vibrate in directions always opposite to each other

be treated on its own merits. The most important ones are discussed in References 1 and 2*.

Natural frequencies of free torsional vibration depend upon the number, inertia and distribution of rotating members and upon the elastic characteristics of the connecting shafts. Usually two simplifying assumptions must be made so that the calculations can readily be performed: One assumption is that each mass is concentrated and can be considered equivalent to a heavy disk; the other is that the intermediate shafting is without appreciable mass compared to the disks, but possesses the proper elasticity. Where such assumptions are obviously far from the truth, as in the case of a long heavy rotor or perhaps a series of closely spaced rotors, cranks, etc., in which neither mass nor elasticity can be ignored, a better approximation is to consider the mass uniformly distributed along the length over which it extends. Extensive discussion of this last treatment is beyond the scope of the present article, but valuable practical data and tables which facilitate solution of problems will be found in Reference 3.

Calculating Natural Frequencies

Simplest case of a setup capable of torsional vibration is the two-mass system such as, for example, a motor driving a radial pump which, in accordance with the foregoing, may be represented by two disks connected by a massless shaft, *Fig.* 47. The only "mode" (manner) in which such a system will freely oscillate is for the connecting shaft to twist and untwist so that each disk deviates from the mean position in a direction opposite to that of the other, *Fig.* 47. On a rotating shaft this means that while one disk is momentarily rotating faster than the average the other is turning more slowly. The system is said to have "one degree of freedom" and it has only one natural frequency of free torsional vibration. The formula for natural frequency is

$$f_n=\frac{1}{2\pi}\sqrt{k\left(\frac{1}{I_1}+\frac{1}{I_2}\right)} \quad \ldots\ldots (1)$$

where f_n is the natural frequency in cycles per second, k is the torsional stiffness of the connecting shaft, including couplings, in inch-pounds of torque per radian of deflection between the two disks, and I_1 and I_2 are the mass moments of inertia of the two disks in pound-inch-second^2 units, calculated from Equation 2. A nomogram for the solution of Equation 1 is given in Reference 4.

The formula for mass moment of inertia is

$$I=\frac{Wr^2}{386} \quad \ldots\ldots (2)$$

where W is the weight of the rotating parts represented by one disk, in pounds, and r is the radius of gyration, in inches. The constant 386 is the acceleration due to gravity, inches per second per second. Values of Wr^2 for motor armatures and other standard parts usually are furnished by the manufacturers.

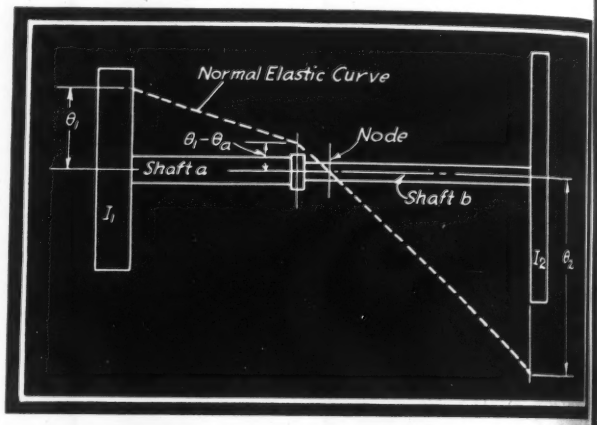


Fig. 48—Normal elastic curve indicates relative vibration amplitude at any point in the shaft at natural frequency

For reciprocating parts incorporated in the system represented by a disk, a good approximation for the equivalent mass moment of inertia is $\frac{1}{2}Wr^2/386$, where W is the weight of the reciprocating part and r is the crank throw or eccentricity, equal to half the stroke.

For a part which is geared to the main shaft, the equivalent moment of inertia referred to the main shaft for the purpose of calculation is given by the equation

$$I_a=I_b\left(\frac{rpm_b}{rpm_a}\right)^2 \quad \ldots\ldots (3)$$

where I_a is the equivalent value referred to the main shaft a and I_b is the actual value for the part itself on the geared shaft b.

Stiffness formulas for shafts are as follows:

For a solid steel shaft (shear modulus $G=11.8\times10^6$)

$$k=\frac{1{,}158{,}460d^4}{l} \quad \ldots\ldots (4)$$

where k is in inch-pounds per radian, d is shaft diameter in inches and l is the length of shaft in inches.

For a hollow steel shaft

$$k=\frac{1{,}158{,}460(d_o^4-d_i^4)}{l} \quad \ldots\ldots (5)$$

where d_o and d_i are the outside and inside diameters of the shaft.

*References are listed at end of article.

For couplings the value of k usually is furnished by the manufacturer.

Inasmuch as connecting shafting usually is made up of two or more diameters and may include a coupling, it is necessary to determine the effective stiffness of the whole assembly. To do this, the stiffness of each individual length and of each coupling is calculated or obtained, then the values substituted in the formula

$$K = \frac{1}{\frac{1}{k_a} + \frac{1}{k_b} + \frac{1}{k_c} + \text{etc.}} \quad \ldots\ldots (6)$$

where k_a, k_b, k_c, etc., are the individual stiffnesses and k is the overall value.

For a geared shaft the equivalent stiffness referred to the main shaft is

$$K_a = k_b \left(\frac{rpm_b}{rpm_a} \right)^2 \quad \ldots\ldots (7)$$

where k_a is the equivalent value referred to the main shaft a and k_b is the actual value for the geared shaft b.

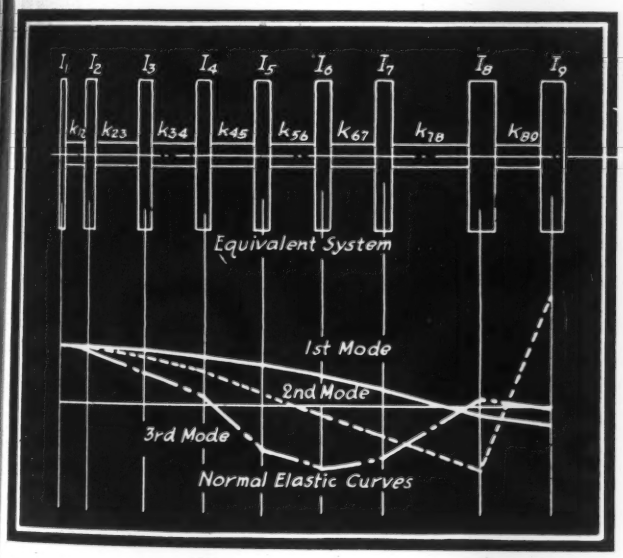


Fig. 49—System of equivalent masses represents six-cylinder engine driving a generator. Curves show relative amplitudes of vibration at the first three natural frequencies

EXAMPLE: To show the use of the foregoing equations, natural frequency calculations will be performed for a simple system in which the two masses are $I_1 = 90$ pound-inch-second^2 and $I_2 = 37$ pound-inch-second^2. The shaft is in two sections, one 2¼ inches diameter by 8 inches long, the other 1¾ inches diameter by 12 inches long, joined by a rigid coupling. The setup is illustrated in *Fig.* 48.

SOLUTION: Stiffness of the first shaft, from Equation 4, is $k_a = 1{,}158{,}460 \times 2\frac{1}{4}^4/8 = 3{,}710{,}000$ inch-pounds per radian. Likewise, for the second shaft $k_c = 904{,}000$ inch-pounds per radian. The effective stiffness of the combined setup, from Equation 6, is $k = 727{,}000$ inch-pounds per radian. The combined stiffness is greater than either of the individual values for the obvious reason that two shafts in series require less torque to twist them through the same total angle. Substituting this value of k, together with I_1 and I_2 in Equation 1, $f_n = 26.5$ cycles per second or 1590 vibrations per minute.

If the torque output or input at either of the two masses is pulsating, there will be, in general, disturbing periodic torques having frequencies which are whole number multiples of the shaft speed. This means that there will be a fundamental critical speed at 1590 revolutions per minute of the shaft, a secondary at 795 revolutions per minute, a third order at 530 revolutions per minute, and so on. The severity of each of these will depend on the magnitude of the disturbing torques and on the friction or damping effects in the machine or at the coupling.

Significance of the Node

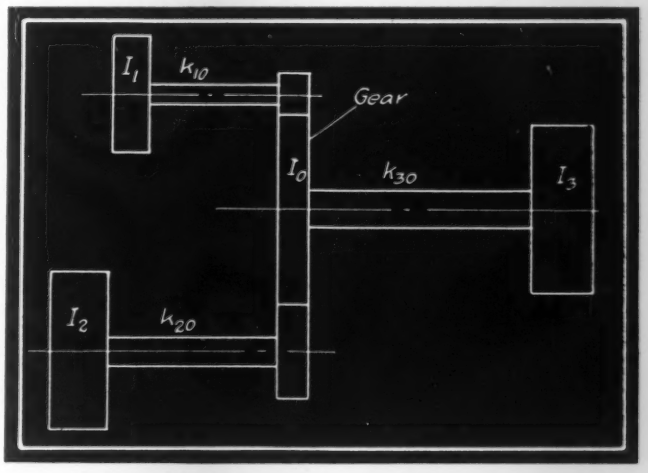
It has been pointed out that at a natural frequency the two masses oscillate in opposite directions to each other. Therefore there is a point in the intermedate shafting which does not oscillate, that is, which experiences no variation in speed. This point is called the "node" and its location often is of importance. For example, the node should be the best point at which to place a gear, because at any other place the oscillation would impose additional fatigue stresses on the teeth as well as transmitting vibration through accessory drives. Also, a pulsating torque applied at the node would be less likely to induce vibration at a natural frequency because of the small vibrational energy input. On the other hand, certain types of vibration damping devices would be ineffective if located at the node because there is no movement for them to work on.

Location of the node is determined by plotting the angles of oscillation at key points on the shaft and finding where the angle is zero. The angle θ_1 and θ_2 at the two disks I_1 and I_2 are related by the formula

$$\frac{\theta_2}{\theta_1} = -\frac{I_1}{I_2} \quad \ldots\ldots (8)$$

The minus sign indicates that θ_1 and θ_2 are of opposite sign. Since only relative angles are needed, θ_1 may be

Fig. 50—Below—Typical branched system, such as this cross-compound geared turbine drive, exists if two or more shafts are geared to another at the same point



assumed equal to 1. For the foregoing example $\theta_2 = -90/37 = -2.435$. On a scale representing the length of the shaft, *Fig.* 48, $\theta_1 = +1$ and $\theta_2 = -2.435$ are laid off. Inasmuch as the twist in any section of the shaft is inversely proportional to the stiffness, the following relations hold:

$$\left.\begin{aligned}\theta_a &= \frac{k}{k_a}(\theta_1 - \theta_2)\\ \theta_b &= \frac{k}{k_b}(\theta_1 - \theta_2)\end{aligned}\right\} \quad \ldots\ldots (9)$$

where θ_a is the twist in that portion of the shaft whose stiffness is k_a, etc., and $(\theta_1 - \theta_2)$ is the total twist between the two disks. In this case $(\theta_1 - \theta_2) = 1 - (-2.435) = 3.435$. Substituting in Equation 9, $\theta_a = .673$ and $\theta_b = 2.762$. The relative amplitude of vibration at the junction of the two shafts therefore is $\theta_1 - \theta_a = 1 - .673 = .327$. This value is plotted in *Fig.* 48. The plotted points are joined by straight lines, and the resulting diagram is known as the "normal elastic curve." The node is at the point where the normal elastic curve crosses the axis and is, in effect, the center of gravity of the system. It should be noted that this curve applies only when the shaft is vibrating at the natural frequency.

The normal elastic curve is a useful aid in determining the stresses in an actual shaft at a critical speed. A torsiograph may be employed to measure the oscillation of a selected point in the system such as, for example, close to the disk 1. Thus, while the machine is running, the

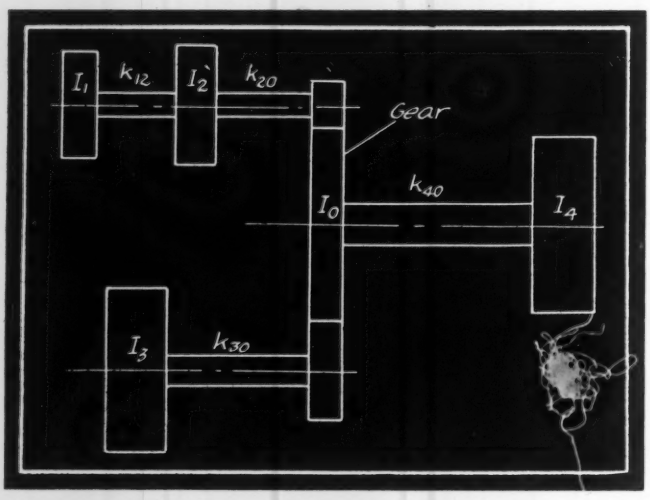


Fig. 51—Branched system with more than one mass on a shaft. Example shows a five-mass system

actual value of θ_1 in degrees can be determined. Values at other points are found from the normal elastic curve by simple proportion. For example, if the value of θ_1 is found to be ¼-degree, the total twist in shaft b would be $\theta_b \times \frac{1}{4} = .69$ degrees. The torsional stress due to the twist θ in a length of shaft l is given by the formula

$$s = \frac{Gr\theta}{57.3l} \quad \ldots\ldots (10)$$

where G = shear modulus = 11.8×10^6 pounds per square inch for steel, r is the outside radius of the shaft, inches, and θ is in degrees. For shaft b the vibration stress, by substitution in Equation 10, is $s = (11.8 \times 10^6 \times .873 \times .69)/(57.3 \times 8) = 15{,}500$ pounds per square inch. In shaft a it is 3240 pounds per square inch.

In a system of rotating parts having more than two masses it often is possible to lump together two or more of the individual masses in order to reduce the whole setup to an equivalent two-mass system. In such a case the equivalent mass should be located at the center of gravity of the group of masses comprising it. The center of gravity is located in the manner already described for finding the node.

Inasmuch as critical speeds may occur at 1590, 795, 530, etc., revolutions per minute, it may happen that one or more of these values falls within the working speed range. In such a case it becomes necessary to change the characteristics of the setup so as to remove the natural frequency from a disturbing frequency. Inspection of Equation 1 will show that to raise the natural frequency, k should be increased (larger shaft diameters or shorter lengths) or the masses I_1 and I_2 should be reduced. Conversely, to lower the natural frequency, k should be decreased or the masses increased. Control of k also may be effected by introducing a flexible coupling between the two units. When the simpler expedients fail to achieve the desired results, as may happen in the case of multicylinder variable-speed engine drives, addition to the system of a damper or absorber unit is indicated. The use of couplings and of absorbers will be discussed later in the present article.

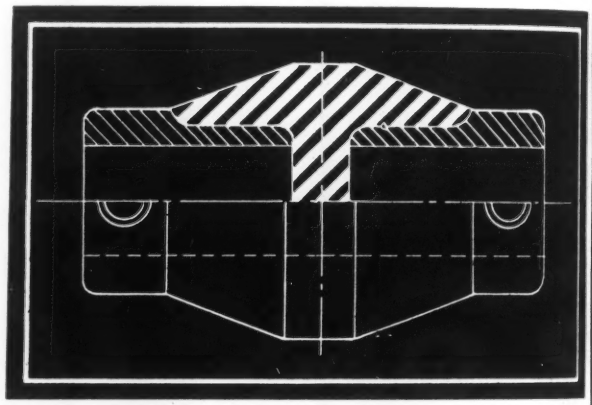


Fig. 52—Rubber coupling, suitable for fractional horsepower sizes, aids in elimination of torsional vibration

Inasmuch as many types of drive include several masses which do not readily lend themselves to lumping into two groups, it is necessary to consider how to find the natural frequencies of a multimass system. Even where such a system can be satisfactorily approximated by two masses in order to use Equation 1 for the solution, such an approximation ignores the fact that a multimass system has more than one degree of freedom, that is, it is capable of free vibration at several frequencies and in different "modes." To illustrate, a 9-mass system consisting of a six-cylinder engine with flywheel and air compressor driving a generator (Reference 1) is represented by the equivalent system shown in *Fig.* 49. The normal elastic curves for the first three modes also are shown. In the first mode, which occurs at a frequency of 1030 vibra-

tions per minute, the location of the node indicates that the flywheel and generator oscillate in one direction while the engine and compressor oscillate in the other. In the second mode (1715 vibrations per minute) there are two nodes, indicating that the flywheel and two of the crank masses oscillate against the rest of the engine and the generator. In the third mode (2935 vibrations per minute) there are three nodes, although one of them is extremely close to the generator.

TABLE I

Calculation of Natural Frequencies of Torsional Vibration

r	I	θ	$I\theta$	$\Sigma I\theta$	k	$\frac{\omega^2}{k}\Sigma I\theta$
1	I_1	$\theta_1=1$	$I_1\theta_1$	$I_1\theta_1$	k_{12}	$\frac{\omega^2}{k_{12}}I_1\theta_1$
2	I_2	$\theta_2=1-\frac{\omega^2}{k_{12}}I_1\theta_1$	$I_2\theta_2$	$I_1\theta_1+I_2\theta_2$	k_{23}	$\frac{\omega^2}{k_{23}}(I_1\theta_1+I_2\theta_2)$
3	I_3	$\theta_3=1-\frac{\omega^2}{k_{23}}(I_1\theta_1+I_2\theta_2)$	$I_3\theta_3$	$I_1\theta_1+I_2\theta_2+I_3\theta_3$	.	. . . . .

Note: If the value assumed for ω in calculating the last column is a natural frequency, then the last value in the $\Sigma I\theta$ column will be zero. If this value is not zero, a new ω must be assumed and the calculations repeated.

In such a system the number of critical speeds is large because of the several modes and the many harmonics in the torque applied at the engine cranks. In a six-cylinder four- stroke cycle engine, which has three firing strokes per revolution, many of the torque harmonics apparently cancel while others, such as the 3rd, 6th, 9th, etc., add. The critical speeds corresponding to those which add are called "major" criticals. For example, the 3rd-order first-mode vibration for the setup shown in *Fig.* 49, occurring at 1030/3 =343 revolutions per minute, is a major critical, and so is the 6th-order second-mode vibration at 1715/6=286 revolutions per minute. Torque harmonics which apparently cancel are responsible for "minor" criticals, though they are not necessarily of minor importance. Because the vibration amplitudes at the six cranks, as indicated by the normal elastic curves, are not equal the energy injuts are not the same so they do not completely cancel each other and the residual energy may be sufficient to cause trouble.

Direct solution for the natural frequencies is impractical where there are more than three masses, hence a trial-and-error method is necessary. Although somewhat tedious, the solution is not difficult and may be systematized and set up in tabular form for handling by nontechnical personnel using a calculating machine. The procedure is to establish the equivalent system of masses and stiffnesses, as in *Fig.* 49, using a consistent notation such as is shown in the figure. The subscripts for k refer to the two masses between which the section of shaft lies.

Basically, the principle of calculation is to assume a frequency and then calculate the normal elastic curve step-by-step, beginning at one end of the system. If the assumed frequency is a natural frequency then the inertia torque at the last disk exactly equals the torque in the last section of shafting. If this is not so, another frequency must be tried. The series of equations for the ordinates to the normal elastic curve are as follows (θ_1 being assumed equal to 1):

$$\left.\begin{aligned}\theta_2&=\theta_1-\frac{\omega^2}{k_{12}}I_1\theta_1\\ \theta_3&=\theta_2-\frac{\omega^2}{k_{23}}(I_1\theta_1+I_2\theta_2)\\ \theta_4&=\theta_3-\frac{\omega^2}{k_{34}}(I_1\theta_1+I_2\theta_2+I_3\theta_3)\end{aligned}\right\}\quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(11)$$

and so forth, where ω is the frequency, radians per second. In general, for the last mass,

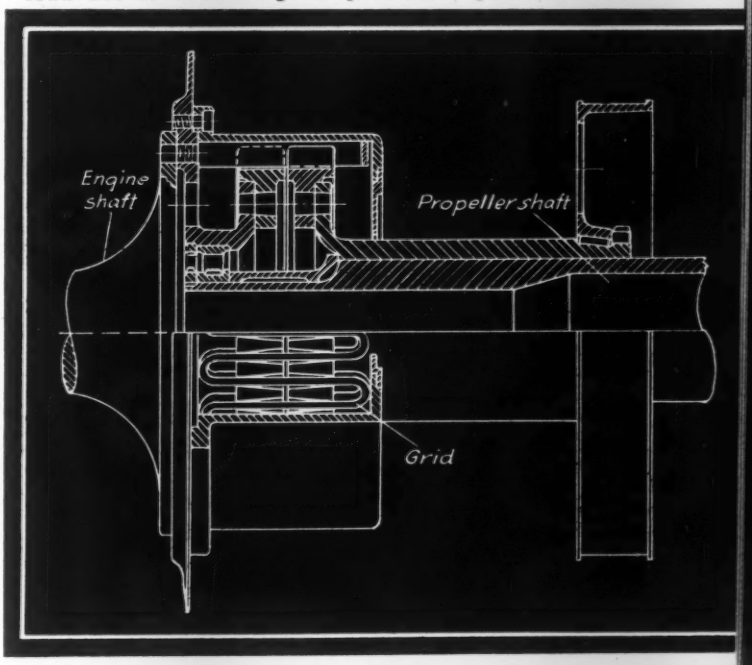
$$\theta_r=\theta_{r-1}-\frac{\omega^2}{k_{r-1,r}}(I_1\theta_1+I_2\theta_2+\ldots+I_{r-1}\theta_{r-1})\quad\ldots\ldots\ldots\ldots(12)$$

where r is the number of masses. If the assumed ω is a natural frequency, then the calculated values of θ_1, θ_2, etc., will satisfy the following equation:

$$(I_1\theta_1+I_2\theta_2+\ldots+I_r\theta_r)=0\quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(13)$$

Tabular solution of the foregoing equations simplifies the work, and the form shown in TABLE I may be employed. To illustrate the use of the table, the symbols for the figures used in calculating a 3-mass system are included. The table may of course be extended to any

Fig. 53—Coupling with flexible steel grid stiffens under load due to shortening of span when grid deflects



number of masses. This form of solution is well known as the Holzer method.

Another type of possible setup in a machine is the so-called "branched system" in which two or more shafts are geared to another shaft at the same point. An example is shown schematically in *Fig.* 50, representing, for example, a cross-compound turbine drive. The two turbines I_1 and I_2 drive a single generator I_3 through a reduction gear I_0. The equations which will be given for finding natural frequencies of this setup apply to similar systems and may be extended to include additional masses. The values for I and k to be used in the equations must be reduced to their equivalent at one of the shafts (shaft 3 for example) using Equations 3 and 7. The trial-and-error solution is performed with the following equations (assuming $\theta_0 = 1$):

$$\left.\begin{aligned}\theta_1 &= \frac{k_{10}\vartheta_0}{k_{10} - I_1\omega^2}\\ \theta_2 &= \frac{k_{20}\vartheta_0}{k_{20} - I_2\omega^2}\\ \theta_3 &= \frac{k_{30}\vartheta_0}{k_{30} - I_3\omega^2}\end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (14)$$

If the assumed ω is a natural frequency, then the calcu-

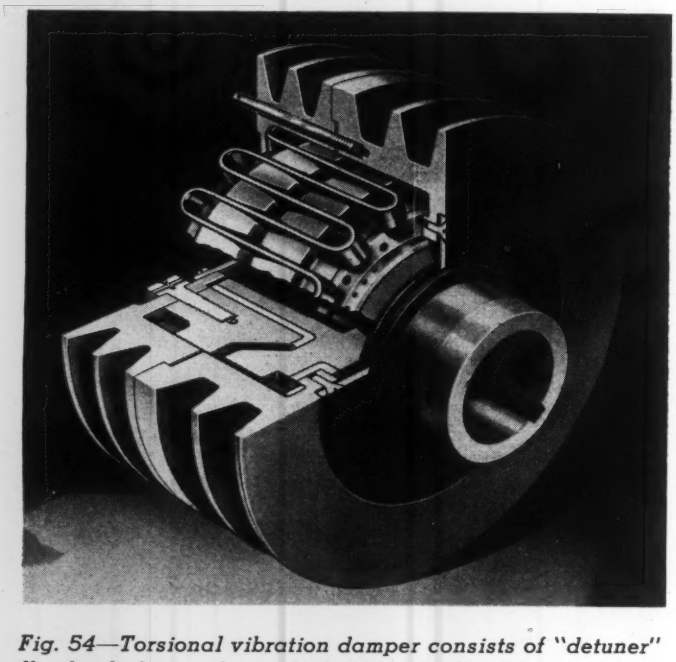


Fig. 54—Torsional vibration damper consists of "detuner" flywheel driven from shaft through flexible steel grid

lated values of θ_1, θ_2 and θ_3 will satisfy the following equation

$$(I_1\theta_1 + I_2\theta_2 + I_3\theta_3 + I_0\theta_0) = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (15)$$

Where there is more than one mass on any shaft of a branched system, as in *Fig.* 51, the following method offers the simplest solution. A tentative value θ_1' is assumed for the amplitude at the end mass 1, and the corresponding value at the second mass is calculated from the relation

$$\theta_2' = \theta_1' - \frac{\omega^2}{k_{12}} I_1\theta_1' \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (16)$$

and the angle at the mass 0

$$\theta_0 = \theta_2' - \frac{\omega^2}{k_{20}}(I_1\theta_1' + I_2\theta_2') \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (17)$$

To obtain the actual angles to use in Equation 15, the tentative values should be multiplied by the ratio (θ_0/θ_0'). Thus $\theta_2 = \theta_2' \times \theta_0/\theta_0'$ and $\theta_1 = \theta_1' \times \theta_0/\theta_0'$. In all cases Equation 14 is the sum of the product $I\theta$ for all masses. For additional masses a similar method is followed, the tentative amplitude being assumed for the end mass and those of the others calculated in succession, using a series of equations similar in form to Equation 11, but with only tentative values of the amplitudes.

As previously mentioned, flexible couplings offer a simple remedy for many torsional vibration troubles. It is important, however, that the stiffness characteristics (k) be known and taken into account; the wrong coupling may be worse than none at all.

For fractional horsepower sizes, small rubber or synthetic rubber couplings, *Fig.* 52, are effective not only in decreasing the stiffness but also in absorbing vibrational energy. Because the stiffness of rubber increases with load, the effective k increases as the torsional deflection increases, thus changing the natural frequency of the setup. It is thus virtually impossible to build up resonant vibration amplitudes. Transmission of noise along the shaft also is prevented. A high degree of flexibility, in effect, isolates the two masses, resulting in the equivalent of two one-mass systems.

Coupling Stiffens Up as It Deflects

A coupling for controlling torsional vibrations in larger sizes is shown in *Fig.* 53. Known as the Steelflex coupling, the device consists of a pair of hubs each provided with specially shaped grooves in their peripheries, to receive a steel grid member. Under light load the grids are supported only at the outer ends of the teeth, as in *Fig.* 53, and power is transmitted through almost the entire length of the flexible grid rungs. As the load increases and the grid deflects, the area of contact increases and the span decreases, stiffening each grid rung against deflection. The k value for such a coupling therefore increases with the deflection (or transmitted torque). As a critical speed is approached and the torsional oscillations increase, the resulting change in stiffness k changes the natural frequency (Equation 1), thus increasing the difference between the disturbing and natural frequencies. This action is known as apparent damping and effectively reduces torsional vibration amplitudes and stresses near the critical. Inherent damping also is present due to friction and slip of the grid members and to transfer of the grease with which it is packed, during oscillation.

The application pictured in *Fig.* 53 represents one of the classic examples of a cure for dangerous torsional vibration. Prior to installation of these couplings, the airship GRAF ZEPPELIN had been forced down due to the

(*Continued on Page* 200)

What the Machine User Wants!

By H. T. Johnson
Director of Standards
General Motors Corp.

Located in the machine base without proper protection, this enclosed motor becomes surrounded with chips which may cause trouble

MUCH HAS BEEN said recently about the probable selling prices of postwar products. Opinions agree that prices of manufactured goods will be higher but differ as to how much higher they will be over prewar levels.

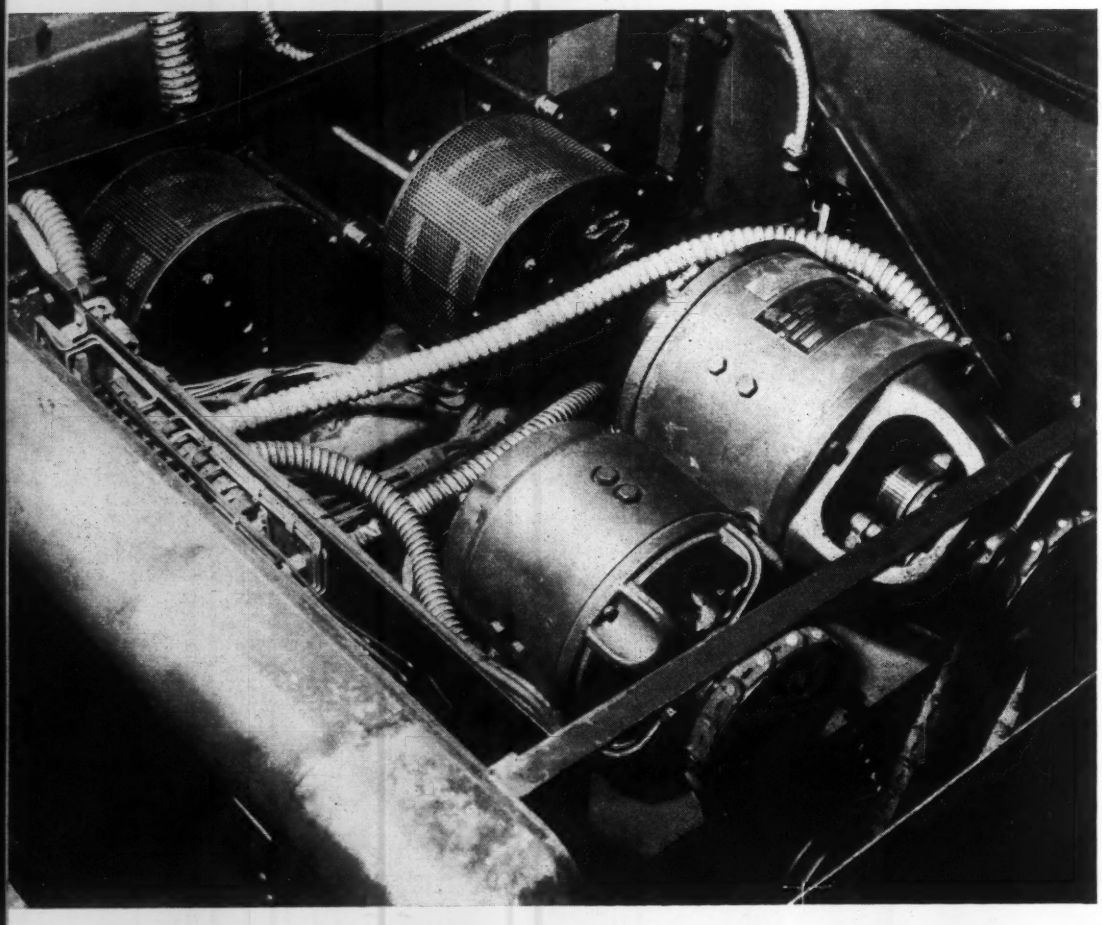
There are actually only two general methods of reducing costs: The first is by design which involves changes in engineering practices, changes in materials or a general cheapening of a product. The second is by improved manufacturing methods and by making full usage of men, machines and equipment.

Insofar as the design of production machines is concerned in reducing operating costs, both convenience in operation and ease of maintenance are of major concern. Neither of these considerations has been given enough attention in the past by either the user or the builder of machine tools.

Every machine designer should imagine himself as being the operator of the machine he is designing. He must visualize just how each control will be operated and he must design the machine so that it requires the least number of the shortest motions possible on the part of the operator, not only to operate the machine but also to load and unload it. He must also design so that it would be impossible for the operator to cause injury to himself or to others. In other words, machines must be so designed that they may be operated conveniently, efficiently and safely and with as little physical effort as possible.

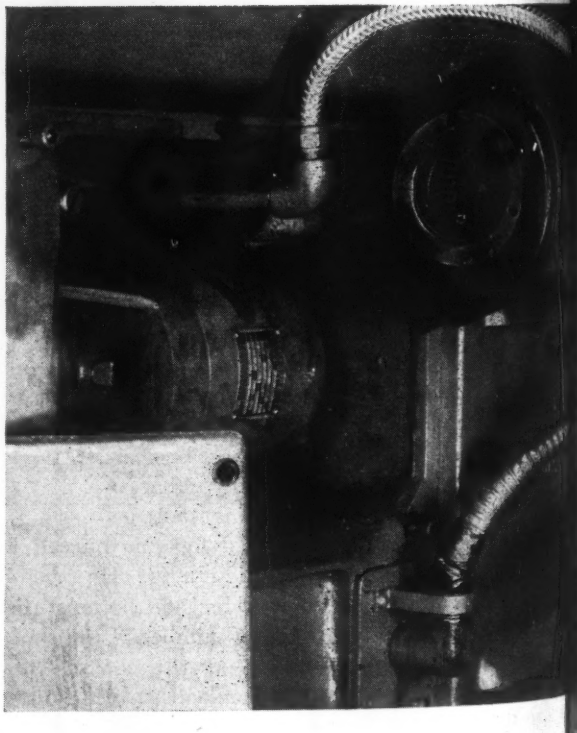
There has been a lot of mystery attached to motion study in the past but it is really simple. All that must be kept in mind is that the movement of any part of the body causes fatigue, consumes time and affects operator morale and costs. We all

PROVISIONS IN DESIGN for ease of operation and facility of maintenance are urged by the author who discusses the user's reactions to certain shortcomings in machines based on his company's experience. Although the article is specifically concerned with machine tools, Mr. Johnson's ideas on misapplications of commercial parts will be read with interest by designers of all types of machines



Left—To remove a motor from this machine base it is necessary first to remove two rheostats and two generators. Also no provision has been made to lubricate the motor

Below—Poor ventilation in compartment necessitates removal of cover and installation of fan so that pump motor would not burn out



believe that machines should extend man's ability to produce. It is, therefore, only logical that the problem of designing machines should be approached with the idea in mind of conserving human energy.

Three things that result from excessive body movements and definitely affect costs are:

1. The operator of a machine that requires long reaches, movement of the body, throwing the body off balance or walking from one position to another will demand more money than if the machine were more easily operated
2. Excessive movements of the body result in excessive fatigue with consequent loss of production as a shift progresses
3. All movements consume time and since we pay for all time consumed on the part of an operator, excessive movements cost more money than short simple movements.

Machine maintenance is a subject that has received little attention since few people have figured out the actual cost. That the machine designer must imagine himself as the operator was mentioned previously. He must also imagine himself as the maintenance man.

The operation of a machine represents direct labor cost which can be controlled within certain limits. But we never know when service will be necessary nor what the cost will be. Most of us consider maintenance costs as only the cost of the labor of the maintenance personnel plus the cost of the materials used. Actually this is far from the case. In fact, it is usually only a small percentage of the total cost of maintenance. There are many other factors involved. A few are:

1. If the down time of a machine is excessive it often is necessary to purchase additional spare machines in order to be sure of maintaining a production rate
2. In addition to paying for the maintenance labor, it is usually also necessary to pay the operator, and often a group of operators, for producing nothing
3. To make up for lost production, it may be necessary to work on Sunday and pay double time although

straight time has already been paid for lost production. In other words, costs for the period have increased threefold

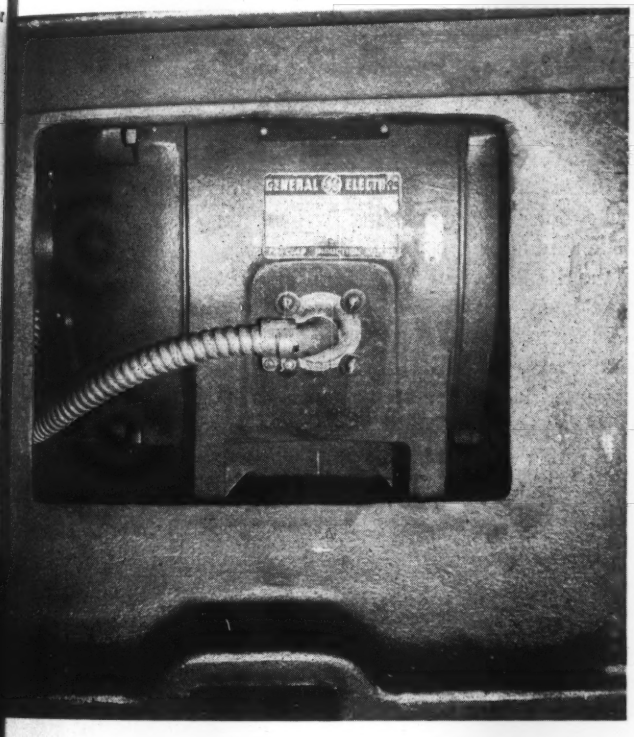
4. Often the lost production can never be made up, resulting in lost sales, and even when production can be made up at a later date sales lost at the beginning of a model year are frequently lost forever.

In a recent case it became necessary to replace a burned out motor in a machine. The down time affected a group of ten men. If there had been no breakdown, the direct labor cost for the parts which would have been produced during the down time would have been approximately $40.00. After adding up the total actual cost which included the labor of the millwrights and electricians, the money paid the group of operators for producing nothing plus the double time paid the operators for working Sunday, a total of $128.00 had been paid to produce parts that should have cost only $40.00. This is an excess cost of $88.00. The millwrights and electricians pay amounted to only $8.00 of the $88.00 excess cost, or 9 per cent.

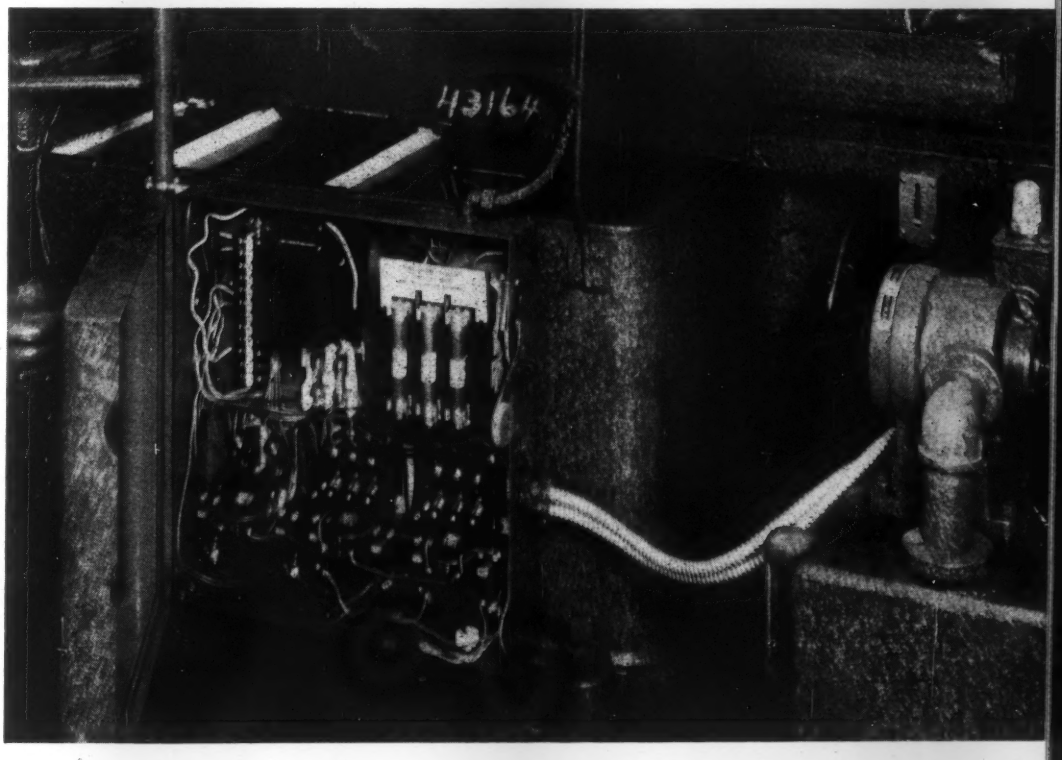
Basically, machine tools do a good job on the operations for which they were designed. As far as machine-cycle time is concerned, they do very well also but that time is, of course, a small percentage of the time paid for. The maintenance cost is a large factor in our costs and the machine designer is the one on whom we must rely to reduce these costs.

Machine tools, during the period of 1936 to 1938, were improved greatly in appearance. This trend has caused a lot of trouble since it resulted in the burying of as many parts of the machine as possible, making them inaccessible and difficult to service or replace. To us it seems silly to "streamline" a machine to the extent that machines are being streamlined today because usually when we get through hanging on disconnect switches, additional chip pans and additional coolant reservoirs the streamlining is ruined.

From the new General Motors machine tool electrical specifications it is apparent that we prefer to have the motor mounted on the outside of the machine. In addition to having them outside of the machine, they should be located high enough from the floor so that they can be serviced easily and are out of the way of dirt and water. Fully enclosed fan-cooled, ball-bearing motors are good looking motors and will not detract from the appearance of a machine. By placing them outside of the machine



Above—Opening in base is smaller than motor, making it impossible to remove the motor without dismantling the machine



Right—Control cabinet is inconveniently located for maintenance, being too near the floor. Also dust and dirt increase the problem in such a location

there is no ventilation problem and they will run for years with no other service than lubrication and occasional cleaning. Also, being in the open they are visible and are maintained much better than when they are out of sight.

In most machine tools today, motors enclosed in compartments are subject to more oil, coolant, chips and dirt than if they were mounted in the open. Ventilation is usually inadequate, resulting in excessive motor burn-outs due to high operating temperatures.

Maintenance Becomes Serious Problem

A few examples of poor motor installations in our plants today include: Two makes of machines where it is necessary to jack up the machine to remove the motor; also several machines in which the replacement of a motor requires from twelve to fifteen hours, lubricating alone being an hour's job. In another popular machine it is practically impossible to remove or install one of the motor hold-down bolts, and in still another machine the conduit that carries the lead wires to the motor runs through the hydraulic sump. In this case, oil vapor collects on the conduit and runs into the terminal box on the motor. In time the motor fills with oil and eventually burns out.

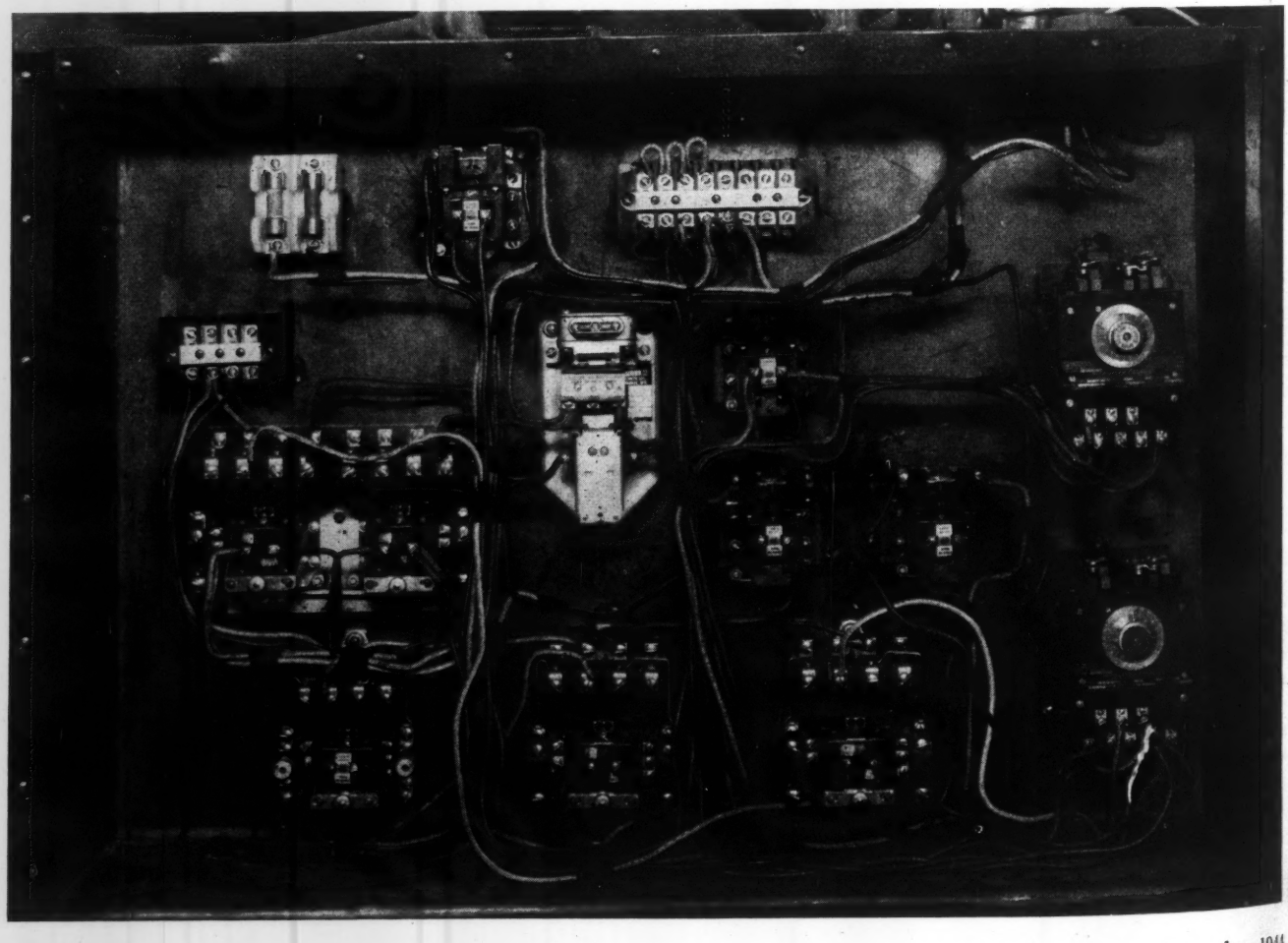
Many control panels buried inside of machines as well as some in enclosures outside of the machines are frequently inadequately protected against oil, dirt, dust and coolant. In some machines electrical controls are scattered in several compartments which makes necessary the removal of several covers and many screws to check trouble. On one machine alone this involves four covers held in place by 68 screws.

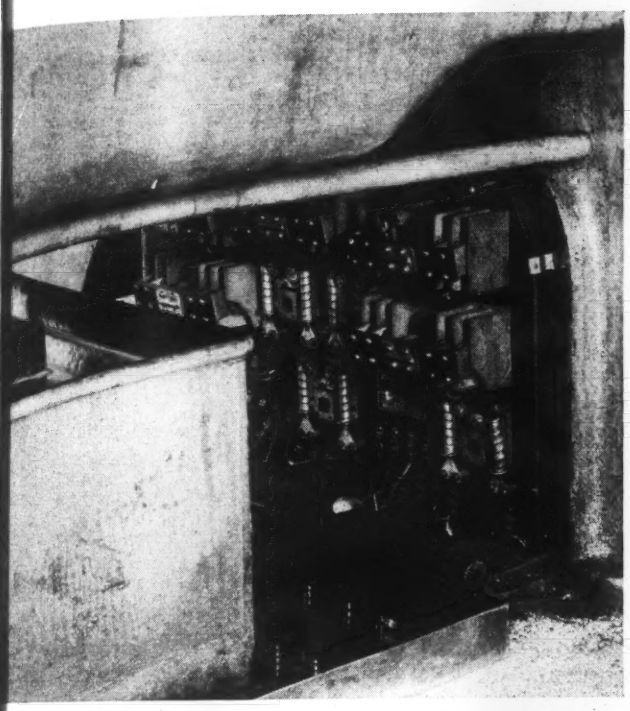
Probably one of the worst practices is the locating of electric control panel enclosures close to the floor where it is both difficult and dangerous to work on them. Often they are so located that every time the floor is swept or scrubbed, dirt and water enters them. In several machines, controls are fastened to panels from the back which makes it necessary to remove the panel to replace a control.

Often limit switches are placed in inaccessible locations and, even though there are dozens of different sizes and types of standard limit switches, a great many electrical engineers of the machine tool builders incorporate ideas of their own in the standard switches. This causes a great deal of trouble. Machines have been damaged due to there being no overtravel protection where limit switches are used. Most limit switches have overtravel protection to protect the switch that costs only a few dollars but the machine itself seldom has any protection if the limit switch fails to function. Several machines have been wrecked and operators injured as a result.

Flexible conduit for wiring, insofar as General Motors plants are concerned, should not be used except where it is impossible to use rigid conduit. Exceptions should be few and far between. The use of flexible conduit is the cause of a large percentage of electric control difficulties.

Below—Poorly wired control panel has a disorderly appearance and makes trouble-shooting difficult





Inaccessible location of controls hampers maintenance. In addition, proximity to coolant reservoir and location beneath bed expose panel to vapor and drippings

It soaks up oil or water like a wick, it breaks loose from connectors and it allows oil and water full access to the controls.

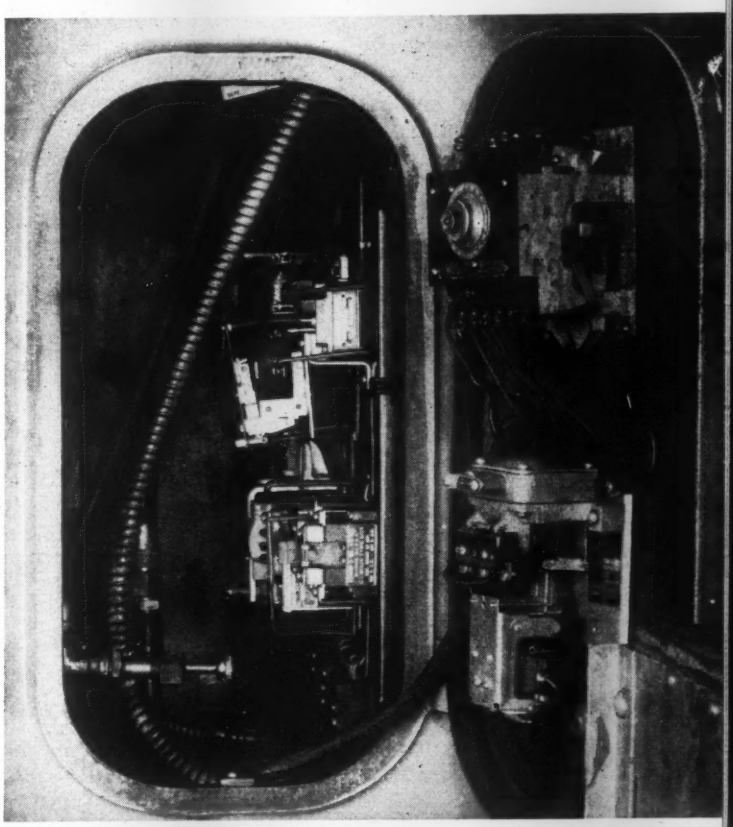
Considerations for Hydraulic Applications

There is no quarrel with the use of hydraulics where they are the best means of accomplishing a result and are engineered so as to be efficient and easily maintained. But many machine tools manufactured today use hydraulics when they are not the best or most efficient means of accomplishing a result. Hydraulic feed on some machines can be replaced by mechanical feed so that the machines operate more efficiently as well as costing less money to build and to maintain. The designer must keep several things in mind to achieve the best results:

1. Hydraulics involve piping, fittings, valves, pumps, and feed cylinders, some of which must sometimes be installed in inaccessible locations. A small leak, a particle of dirt, a little air in the system or even a rise in temperature can make any of this apparatus inoperative.
2. Hydraulics, particularly an inefficient installation, introduce temperature problems. Engineers who would work for weeks to eliminate the waste of power due to friction or other causes will use a hydraulic circuit where gallons and gallons of oil are pumped per minute, by-passing what isn't needed to operate the machine. The resulting temperature problem has become serious because, in many cases, instead of correcting the trouble by using an efficient circuit, a complicated refrigerating or ventilating system is added.
3. Use of hydraulics involves a maintenance problem that is serious. Hydraulics are peculiar in that a symptom of trouble does not always indicate the same thing. In the case of electrical circuits an average electrician with a battery and buzzer can locate trouble. In the case of mechanical functions a mechanic can usually locate trouble in a short time. But, in the case of hydraulics, the experts often require hours to diagnose the trouble.
4. Use of hydraulics involves the finding of room in the machine for an oil reservoir of sufficient capacity, a pump and its drive motor, valves, piping and one or more feed cylinders.

Production Limited by Chip Disposal

Chips and coolant are another of our major problems, mainly due to the fact that the machine builder does not provide adequate facilities or protection. This criticism applies to all types of machines—mills, drills, lathes and grinders; in fact, grinders are often the worst offenders. The machines have been made more powerful to remove



Control compartment is too restricted for servicing. Hydraulic and electric controls are in same compartment, increasing maintenance difficulties

stock faster, but no provision has been made to filter the sludge out of the coolant or to control the temperature of the coolant so that the accuracy of the work will not be affected.

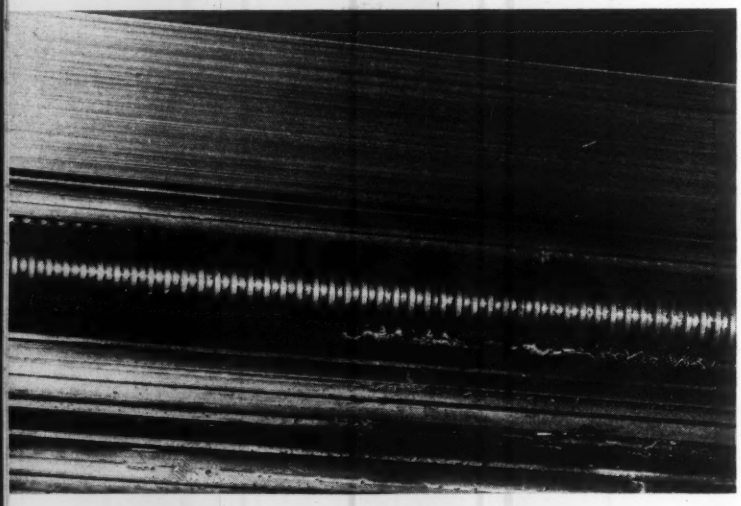
Talking of removing material in the future at rates of two to six times greater than at present is futile when neither the chips nor the coolant can be handled at the present rate of stock removal. We have several machines, particularly mills and lathes, operating with tungsten carbide on which the rate of stock removal is limited entirely

by the handling of chips and coolant.

Designers must certainly get busy on this problem. Provisions should include more room in chip troughs and between ways, mechanical means of separating chips from coolant and conveying them to an accessible place for disposal, better protection of electrical equipment, better protection of feed operating plungers and trip dogs, larger coolant pumps and reservoirs with means for controlling coolant temperatures.

To summarize and to make clear what we would like to have the designer keep in mind when developing machines in the future, the following ten points merit consideration:

1. An attempt should be made to standardize the component parts of machines.
2. Feeds and speeds must be increased to take advantage of new cutting techniques. Machine tools must be furnished with feed and speed ranges which make it unnecessary to purchase partial ranges. Machines must also be more powerful. Spindles, particularly on milling machines, should be equipped with flywheels and gear-train vibration must be eliminated.
3. The designer should weigh carefully all of the advantages and disadvantages of the various types of feeds before definitely deciding on any one.
4. Electric controls should be used wherever possible. Care should be taken, however, to make sure that the controls and wiring are dependable and accessible for servicing.
5. Postwar machines as a whole will not be required to produce a better quality of finish than being produced today. It will, however, be necessary to produce more rigid machines in order to produce present quality of finish at higher feeds and speeds.
6. Chip disposal is a serious problem today. Present chip disposal arrangements are not satisfactory even for present rates of metal removal. This limitation may be a deciding factor in obtaining maximum production from the postwar machine tool.
7. Lubrication facilities must be improved to the point where every bearing possible is automatically lubricated. More attention should be paid to the use of filters and piping of adequate size. When it is not possible to lubricate bearings automatically, lubricating fittings should be made as accessible as possible and plainly marked.
8. Hardened and ground ways are desirable on practically every type of machine tool, particularly on those where the table or slide is so short that prolonged operation at one set cycle will result in excessive localized wear. It must be remembered that production machines usually run on one operation for periods of time of a year or more. Frequently, when changing machines over to operations requiring longer or shorter strokes than previously used, it is necessary to remachine conventional beds, slides and tables.
9. Electronic controls are desirable but they should be dependable and all controls and wiring should be accessible. Here there also is need for a standardization program before the use of electronics becomes too widely used.
10. Controls must be placed in safe and convenient locations. All controls should be located so that the operator can reach them while he retains a normal posture. All unnecessary motions must be eliminated and necessary motions must be as short as possible. Also, there should be no projections or obstructions which make necessary unnatural postures on the part of the operator.



Inadequate provision for chip removal resulted in unnecessary damage to this lead screw

Sprayer Utilizes Airplane Propellers

COVERING as much acreage as could be handled by four ground crews, the insect sprayer illustrated throws as much as 100 gallons of bug killer per minute. Utilizing two "wind tunnels" with five airplane type propellers in each, the unit is powered by a 110-horsepower six-cylinder tractor engine. Despite the 2.6 velocity pressure of air and 40-pound pressure on the nozzles which feed the wind tunnels there is no sign of damage to foliage. Fruit trees may even be sprayed in bloom. Designed by Food Machinery Corp., the first commercial model was designed in 1939 and mass production was started in 1942.

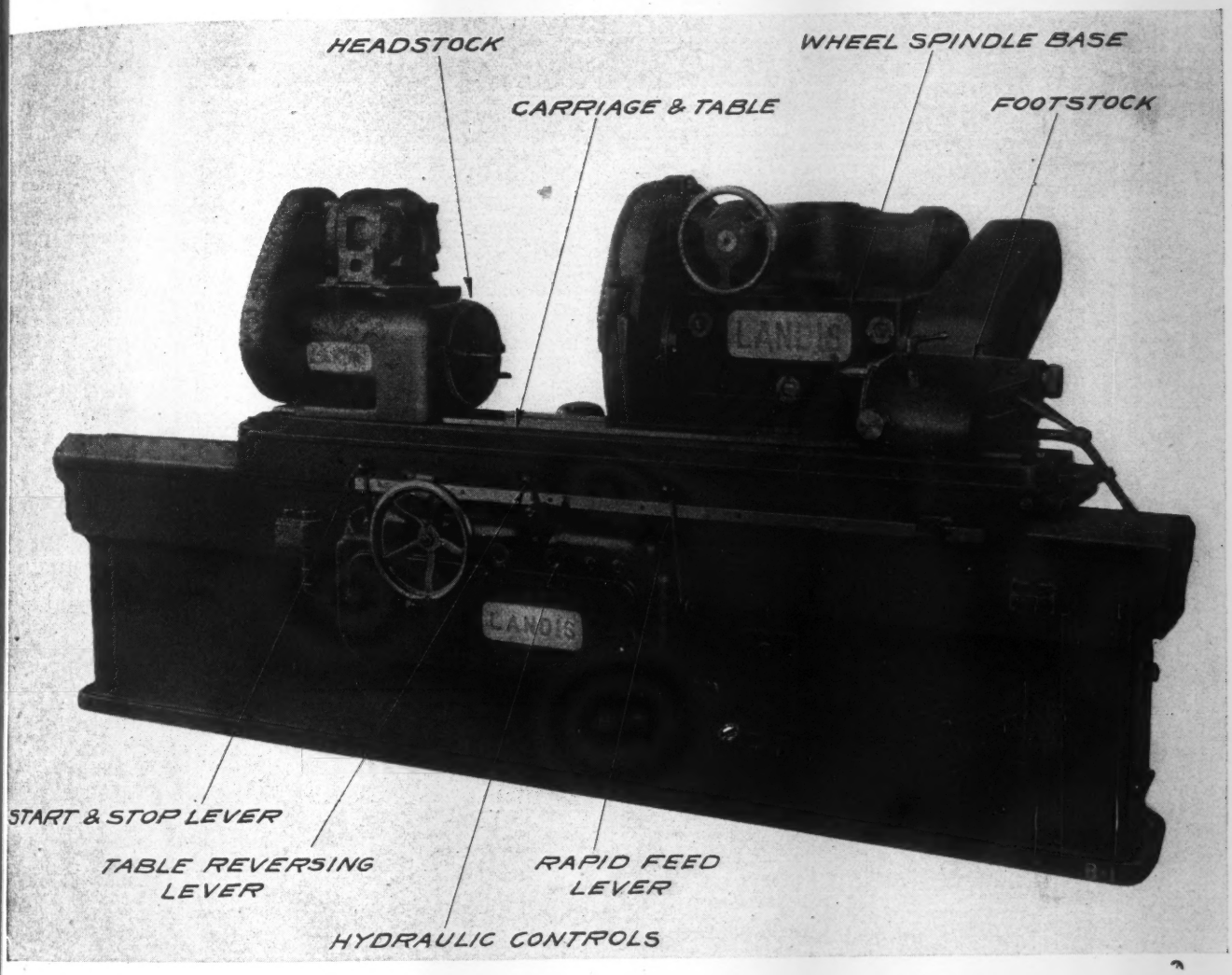


Fig. 1—Arrows indicate major units of hydraulic cylindrical grinder

Utilizing Hydraulics In Cylindrical Grinder

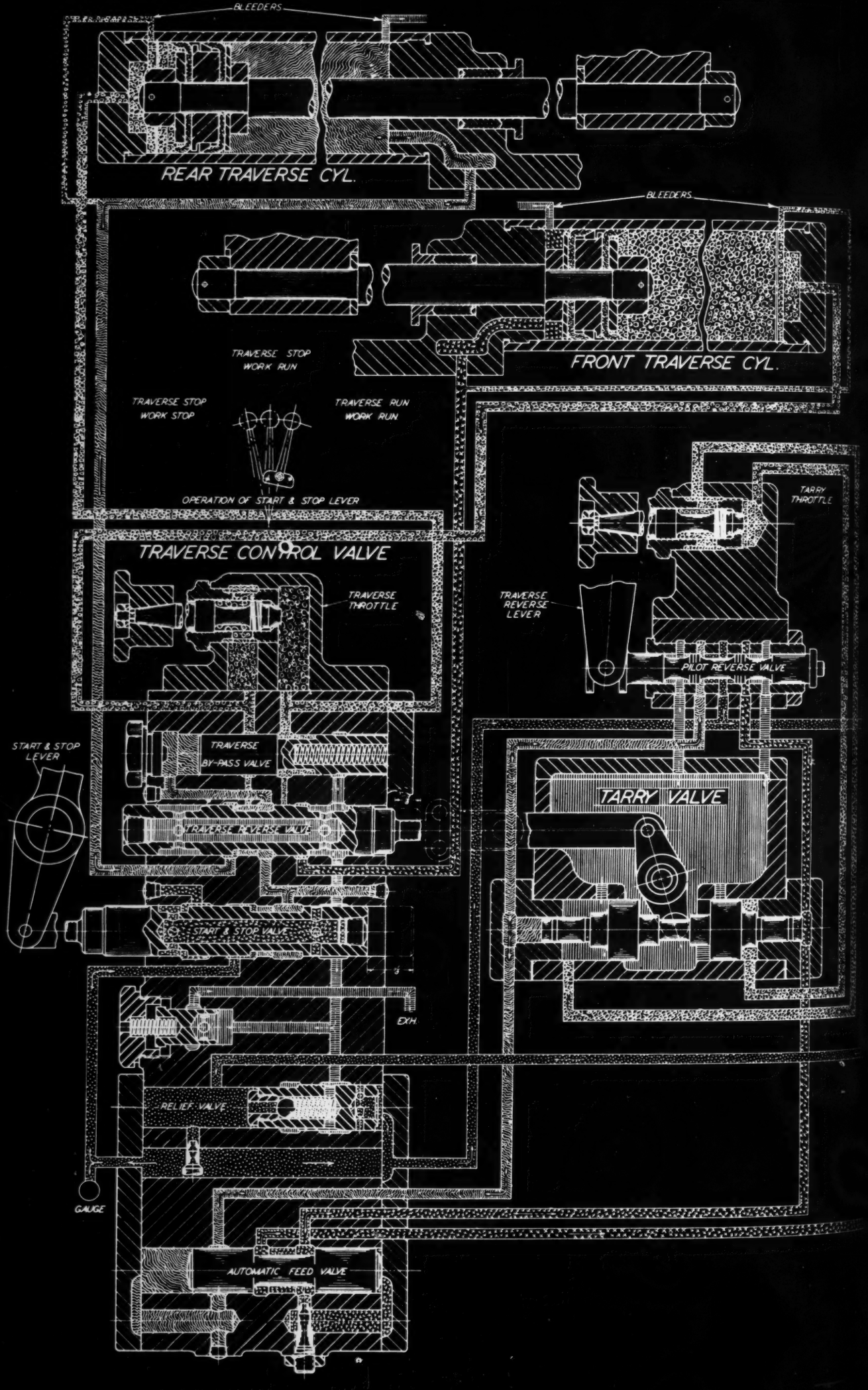
By F. A. Firnhaber
Standards Engineer
Landis Tool Company

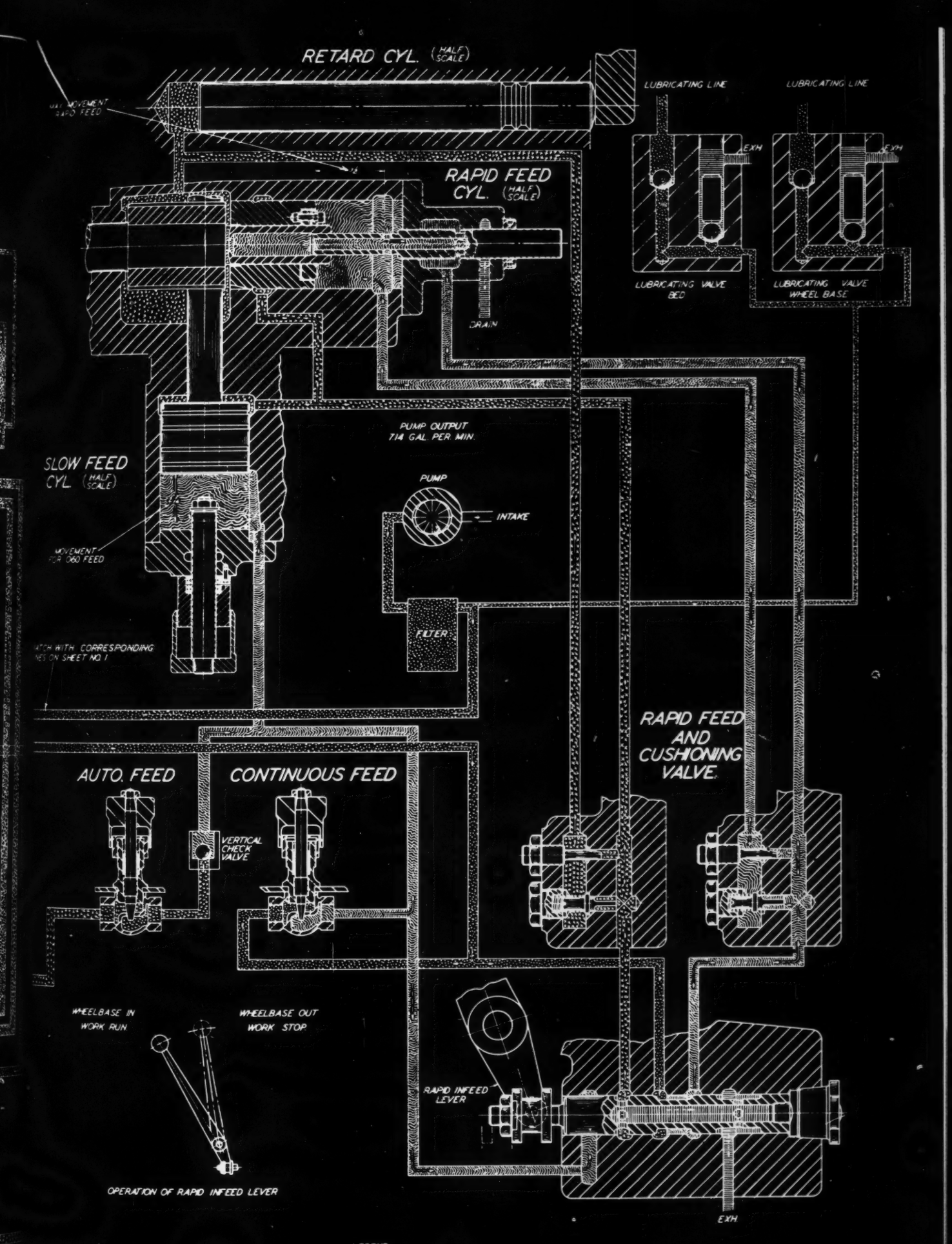
FUNDAMENTALLY, there are two basic linear movements in a present day cylindrical grinding machine. First, the table and carriage unit, upon which are mounted the head and footstocks and auxiliary rests for supporting the work to be ground, reciprocates at any speed and any length of stroke desired within the range of the machine. Second, the wheel base unit, supporting the grinding wheel and spindle, is fed forward into the work in a direction usually at right angles to that of the carriage and table. These units are shown in *Fig.* 1.

Because of the variations required in these two basic movements, mechanical means of accomplishment have long since been discarded. It has been proved that the most successful method for obtaining these various functions is through the medium of hydraulic power. Use of hydraulics in the cylindrical grinder has eliminated shock to such an extent that much finer finish is produced on the work. Further, noise, always present in load-and-fire arrangements of reversing clutches, has been eliminated.

It is a well known fact that speeds and feeds obtained by hydraulics are infinitely variable, a characteristic most

Fig. 2—Next page—Hydraulic circuit diagram of grinder


BLEEDERS
REAR TRAVERSE CYL.
BLEEDERS
FRONT TRAVERSE CYL.
TRAVERSE STOP
WORK RUN
TRAVERSE STOP
WORK STOP
TRAVERSE RUN
WORK RUN
OPERATION OF START & STOP LEVER
TRAVERSE CONTROL VALVE
TRAVERSE
THROTTLE
TARRY
THROTTLE
TRAVERSE
REVERSE
LEVER
PILOT REVERSE VALVE
START & STOP
LEVER
TRAVERSE
BY-PASS VALVE
TARRY VALVE
START & STOP VALVE
EXH.
RELIEF VALVE
GAUGE
AUTOMATIC FEED VALVE


RETARD CYL. (HALF SCALE)
RAPID FEED CYL. (HALF SCALE)
SLOW FEED CYL. (HALF SCALE)
RAM MOVEMENT RAPID FEED
RAM MOVEMENT FOR 060 FEED
LUBRICATING LINE
LUBRICATING LINE
EXH
EXH
LUBRICATING VALVE BED
LUBRICATING VALVE WHEEL BASE
DRAIN
PUMP OUTPUT 714 GAL. PER MIN.
PUMP
INTAKE
FILTER
MATCH WITH CORRESPONDING LINES ON SHEET NO. 1
AUTO. FEED
CONTINUOUS FEED
VERTICAL CHECK VALVE
RAPID FEED AND CUSHIONING VALVE
WHEELBASE IN WORK RUN
WHEELBASE OUT WORK STOP
RAPID INFEED LEVER
EXH
OPERATION OF RAPID INFEED LEVER
LEGEND
CONTROL
PRESSURE
EXHAUST
ALTERNATELY PRESSURE & EXHAUST
PRESSURE & EXHAUST

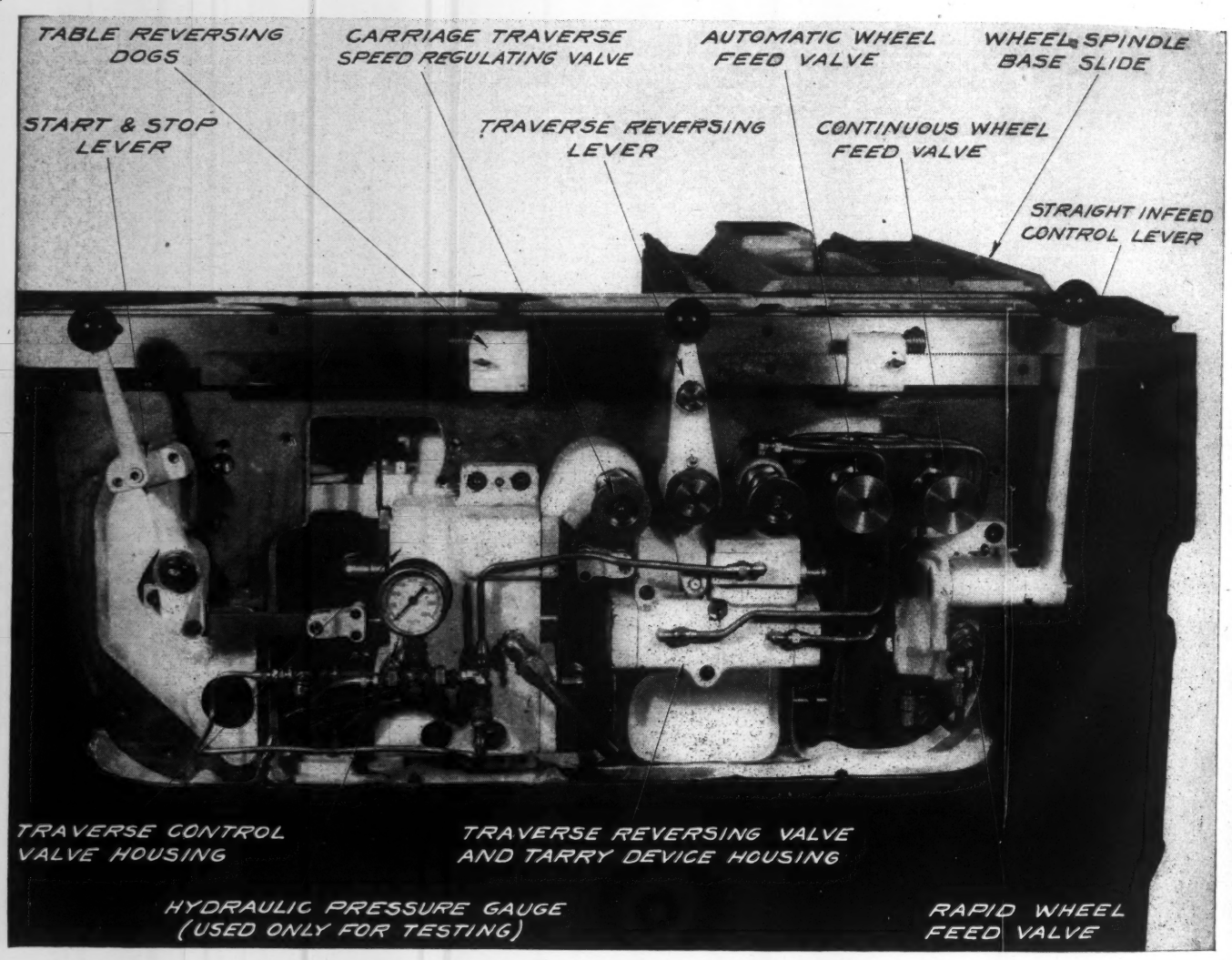


Fig. 3—Arrangement of hydraulic components in grinder. Pressure gage is removed after being used for testing

applicable to and desirable in fine finishing machines. Flexibility of working cycle, ease and simplicity of operation and manipulation, and maintenance costs in the low brackets, all are contributing factors to the choice of hydraulics as motive power for this type of machine.

The comparatively heavy table and carriage together with the work supporting fixtures, travels at a maximum speed of 240 inches per minute. At this speed, deceleration, stopping, reversing, acceleration and then deceleration again, all act with a great degree of smoothness and steadiness when controlled hydraulically. Consistent accuracy of reversal has been found to be greater than when clutches were used for this operation. It is now possible to grind work within .002-inch of a shoulder and maintain this accuracy, when previously by mechanical means, five times that amount was considered good.

An adjustable dwell or tarrying period, during which time the table and carriage unit is motionless, is worked into the cycle, the dwell occurring at the end of each stroke. For this time-adjustment and adjustment of rate of speed at which the table travels, all that is necessary in the hydraulic line is a control valve for each function. To do this mechanically, even a limited number of adjustments could not compare with hydraulics, primarily because of the numerous parts that would be involved.

Movement of the wheel base toward or away from the work involves other variables. A fast forward movement or rapid advance is required to bring the wheel up quickly to reduce idle time to a minimum. From the time the wheel touches the work a slow rate of continuous feed is required, the speed of the advance being controlled by the continuous-feed rate valve.

Into the latter is incorporated another auxiliary movement in which an extra shot of oil through the automatic feed valve moves the wheel base into work engagement by a preset rate of intermittent feed for a total of .060-inch.

When a so-called plunge-cutting operation is performed by grinding, the traversing carriage and table are locked in position and only the wheel base or cross movement is operative. The various combinations of fast and slow movement of the wheel base can be used during this straight infeeding movement.

All of these different movements are accomplished by the medium of hydraulic power, the fluid being under a pressure of 200 to 250 pounds per square inch. For carriage and table traverse there are two cylinders mounted directly beneath in a depression in the top of the bed upon which the unit slides. The piston rods are connected to brackets at each end of the carriage. As can be seen in the upper left-hand corner of the hydraulic diagram shown in *Fig.* 2, pressure is applied to the right-hand end of the rear traverse cylinder, thereby moving

the carriage toward the left. Concurrently, the oil is forced out of the left-hand end of the cylinder, through the traverse control valve and then into the right-hand end of the front traverse cylinder. Also at the same time, oil is being forced out of the left-hand end of this cylinder through the traverse reverse valve. It is apparent that the inner ends of the cylinders are alternately under pressure and exhaust. This commonly is called a locked hydraulic circuit.

Unique Throttle Valve Employed

Oil at the outer ends of both cylinders is forced through a unique throttle valve. In addition to the customary tapered opening the oil must also pass around a shallow acme-like thread which further tends to provide a finer metering control. This oil acts as a cushioning agent against the pressure at the opposite end of the cylinders and controls the speed of the carriage and table movement.

Of course this means the piston is locked between the pressure of oil at the operating end of the cylinder and that at the exhaust end. From the hydraulic diagram, it will be seen that the bleeder lines have been located at the upper side of the cylinders. The advantage of this is in maintaining the maximum amount of oil, free from air bubbles, in this part of the system.

The table and carriage traverse control valve is part of the unit which houses several other valves used in conjunction with and for the desired functioning of the traverse control valve. Filtered oil enters this valve housing from the pump, as the circuit diagram shows, and oil under excess pressure is exhausted. The oil then passes through a relief valve to the start and stop valve. At this point a gage to register the proper pressure for the system is attached when it is desired to check. *Fig.* 3 shows the gage in place. However, after checking, the gage is removed so that it is not constantly subjected to pressure. The relief valve referred to is so constructed that not only is the oil under excess pressure by-passed, but the viscosity of the oil is compensated for also. Regardless of temperature, the volume of fluid passing through into the system remains constant. The amounts of cold sluggish oil or warm thinned oil each having a different rate of flow, are balanced by the action of the sliding valve shown.

Located at the left of the start and stop valve is its actuating lever which has three positions of control. When the upper end is toward the left, the work and table are at rest. Moved to a central position the work revolves but table traverse is stationary. Moved to the left as illustrated, both the work and table are in motion. At this time, as can be seen in the diagram, the oil travels around the start and stop valve to the traverse reverse valve from where it enters, under pressure, the right end of the rear traverse cylinder. At the same time the oil is directed to the left end of the traverse by-pass valve, moving it to the right and compressing the spring. This action closes off the oil in the traverse cylinders thereby causing a flow through the traverse control valve from the left-hand end of the rear cylinder to the right-hand end of the front cylinder. This control valve determines the traverse speed of the carriage and table.

There are two small central passages connecting the traverse reverse valve and the by-pass valve. They are so arranged as to insure that this locked oil system is kept full and free from air while under pressure, preventing drainage of the oil from the cylinders. When the start and stop lever is shifted to the stop position, the pressure is removed from the left end of the traverse

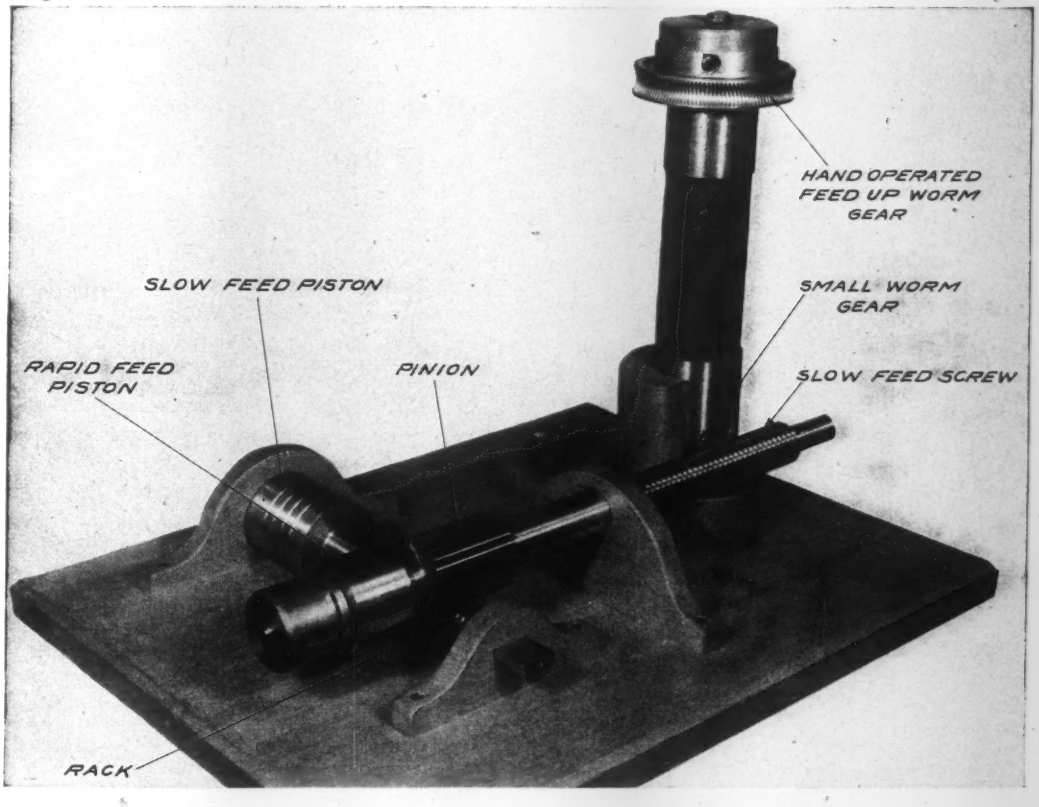


Fig. 4—Model shows how motions of slow-feed screw, rapid-feed piston and slow-feed piston are effected

by-pass valve, the spring forcing it to the left. In this position the oil in the cylinders by-passes the throttling needle of the traverse control valve and permits a free flow of oil from one cylinder to the other while the carriage and table are traversed manually.

Reversal of the carriage and table unit is accomplished by use of a pilot valve operated by the traverse reverse lever either manually or automatically, the latter by dogs, one at each end of the table stroke. To have a timed dwell at the point of reversal, a dwell valve is incorporated and consists of a pair of opposed pistons connected through a link and lever mechanism to the traverse reverse valve. Both of these valves are contained in one housing as shown in the photograph, *Fig.* 3.

Fluid under pressure enters the pilot valve from the pump. By movement of the lever the fluid is directed to the left end of the dwell valve which moves to the right. The lever engaging the middle of this valve, being connected by a link and coupling to the traverse reverse valve, shifts the latter to the left (see circuit diagram). The opposite takes place when the reverse lever, actuated either by hand or power, is shifted to the left.

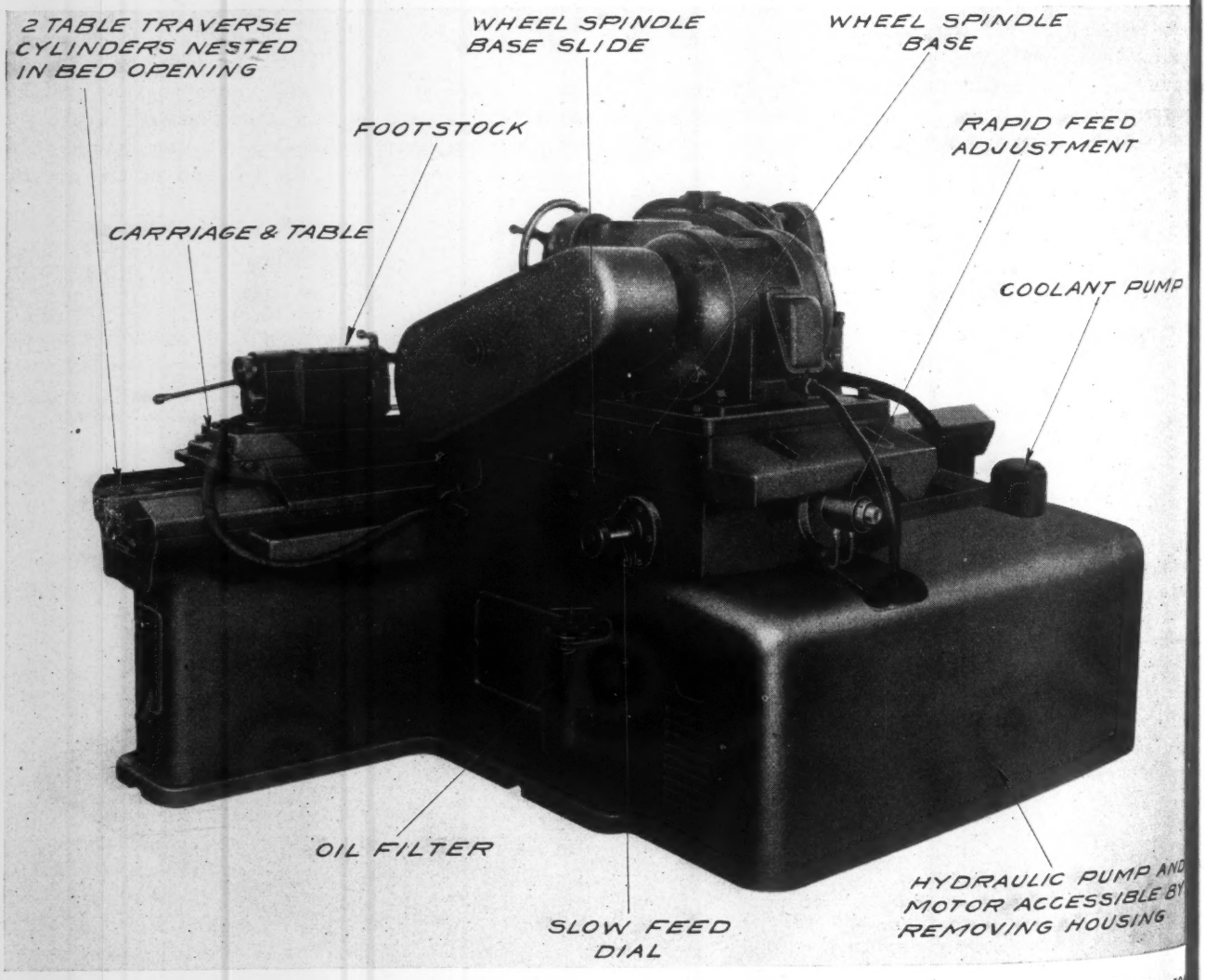
As the dwell piston shifts to the right the oil behind the large right-hand end is exhausted into the reservoir within the housing directly above this valve until t valve spool closes off the hole. At this point the trave reverse valve is in its central position so that moveme of the carriage and table is stopped immediately. W the closing of the passage to the reservoir the oil und pressure at the right of the dwell piston must pass throu the dwell throttle valve shown above the reverse val housing in the hydraulic diagram. This valve is of th same construction as that of the traverse control val and has the same minute metering capacity so that th length of dwell can be controlled accurately.

Actuating the Reverse Valve

Further movement of the dwell valve, however slo finally opens a port connecting the hollow part of th dwell spool valve to the passage to the reservoir, whe the fluid under pressure is released from the right-han end of the dwell valve directly to the reservoir. Th gives a rapid movement to the reverse valve from i central position to that of the reverse position. As th takes place the oil from the reservoir is admitted to th other end of the dwell valve spool in preparation f movement of the mechanism in the opposite directio The oil in the reservoir of the dwell valve housing is r

(*Continued on Page* 208)

Fig. 5—Rear view of grinder shows how various hydraulic units are located to offer ready accessibility



Why Not Standardize Now?

ENGINEERING standardization can be given credit in large measure for the tremendous production of war equipment achieved over the past three years. Utilization of standards in design and manufacture, on equipment ranging from the humble jeep to the highly refined Superfortress, has aided production to an untold degree in far-flung areas and widely diversified types of plants.

One phase of standardization—of an international character—still has a long way to go, however, as brought out by William L. Batt at a recent meeting on standards held in New York. He estimated that at least $100,000,000 had already been added to the cost of the war and claimed that innumerable delays in production and maintenance have been caused through differing standards in the United States, Britain and Canada.

Primarily responsible is the lowly screw thread, early efforts at the standardization of which, between the three countries, have proved of no avail. This condition has led to unlimited difficulty and delay because even on war equipment of supposedly identical design the parts are not interchangeable due to the difference in American and British screw-thread practice.

That there is some possibility of relief from this situation in the comparatively near future now seems evident through close collaboration between the countries concerned. It is earnestly to be hoped that the attempts at unification started this year and now continuing will result in early agreement, and that efforts to arrive at other mutually agreeable engineering standards—such as those governing cylindrical fits—will be successful.

Immediate adoption of such standards by industry in the three countries concerned might well prove exceedingly beneficial, particularly on the fighting fronts where the slighest delay in maintenance and repair can have disastrous results.

L. E. Jermy

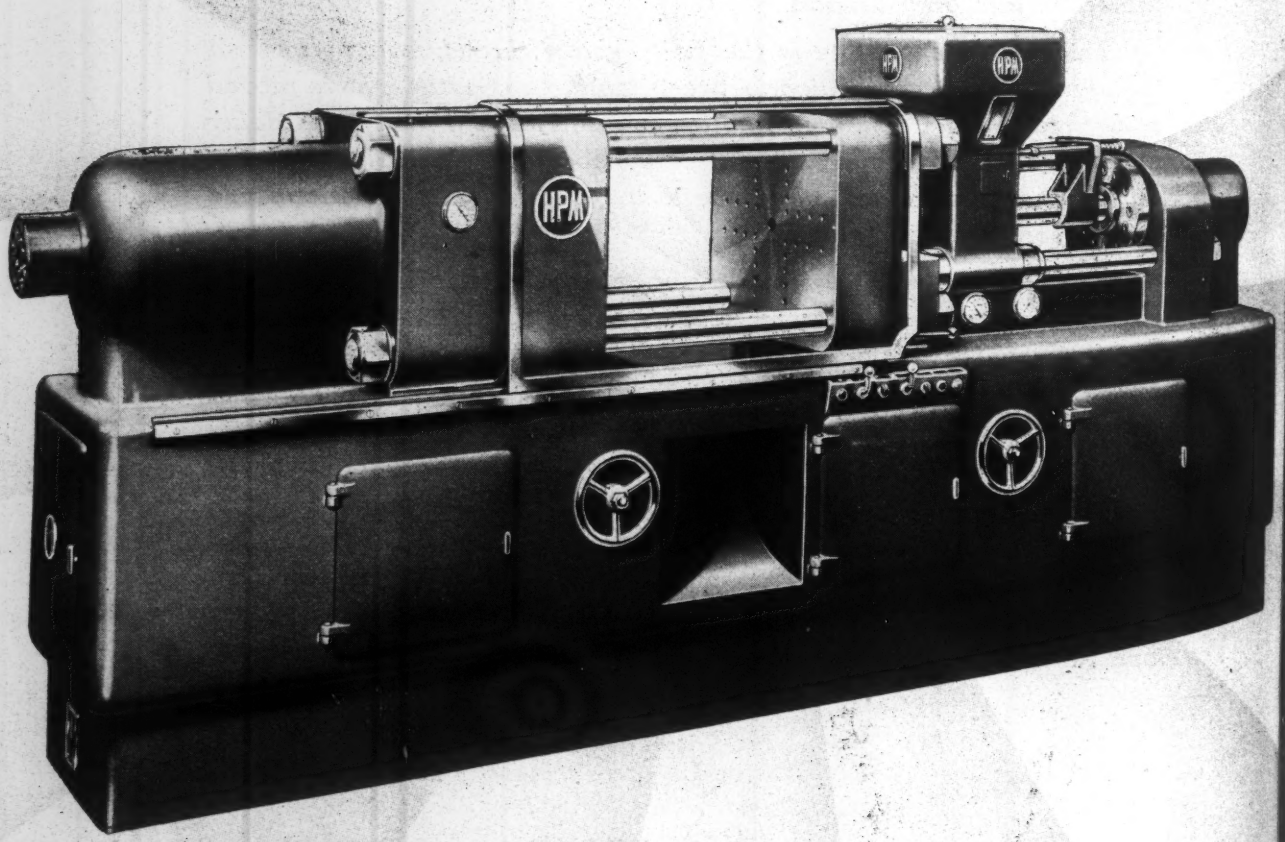
Outstanding Designs

Plastics Injection Molding Machine

With base of welded heavy formed-steel plate construction fitted with hinged doors for access to the hydraulic power unit and controls, this machine has been developed by the Hydraulic Press Mfg. Co. for the postwar market. Two radial hydraulic pumps, direct-connected through flexible couplings to a double-ended shaft electric motor are provided. One pump powers the mold-clamp unit and the other powers the injection unit.

Injection chamber of the machine is provided with two heating zones separated by an insulating air gap. Electric band heaters are employed in conjunction with indicating temperature controls. Hopper for the plastic material is of cast aluminum with sloping bottom and smooth interior finish. It is equipped with a window for visual checking of its contents.

Main operating valves are actuated by solenoids, direct mounted without intervening linkage. A single timer is provided for controlling the clamp and injection actions. The injection chamber is mounted on a steel cradle which is held in accurate alignment on two tie rods.

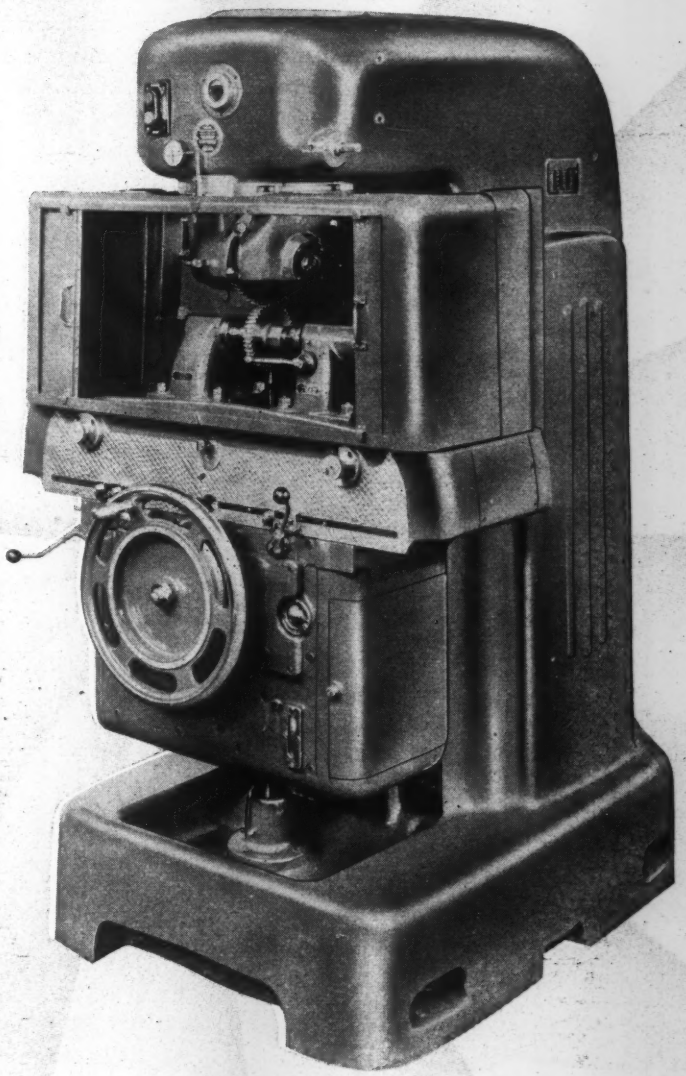


Gear-Tooth Shaving Machine

Both the horizontal reciprocating movement and vertical feed of the table of this gear-tooth shaving machine are automatic. Change gears provide the necessary range of table speeds and maintain a constant rate of feed. The cutter spindle, speed of which is adjustable through change gears, is 2½-inches in diameter, giving ample rigidity to offset the pressure developed during actual tool contact.

A development of the National Broach and Machine Co., this machine utilizes individual motors for the cutter spindle, table feed and oil pump. The electrical controls employed are recessed in a panel in the machine frame and include a safety disconnect switch. Forced-feed lubrication is provided for all moving parts in the knee, and oil-level gages indicate the amount of lubricant available for distribution. A 30-gallon tank in the column provides ample coolant for any type of operation.

Head of the machine is movable about a vertical axis and may be adjusted precisely with a vernier scale, sine-bar buttons and indicator, to bring the axis of the cutting-tool arbor—mounted in the head—to the desired angular relation with the fixed work-gear arbor on the table beneath.



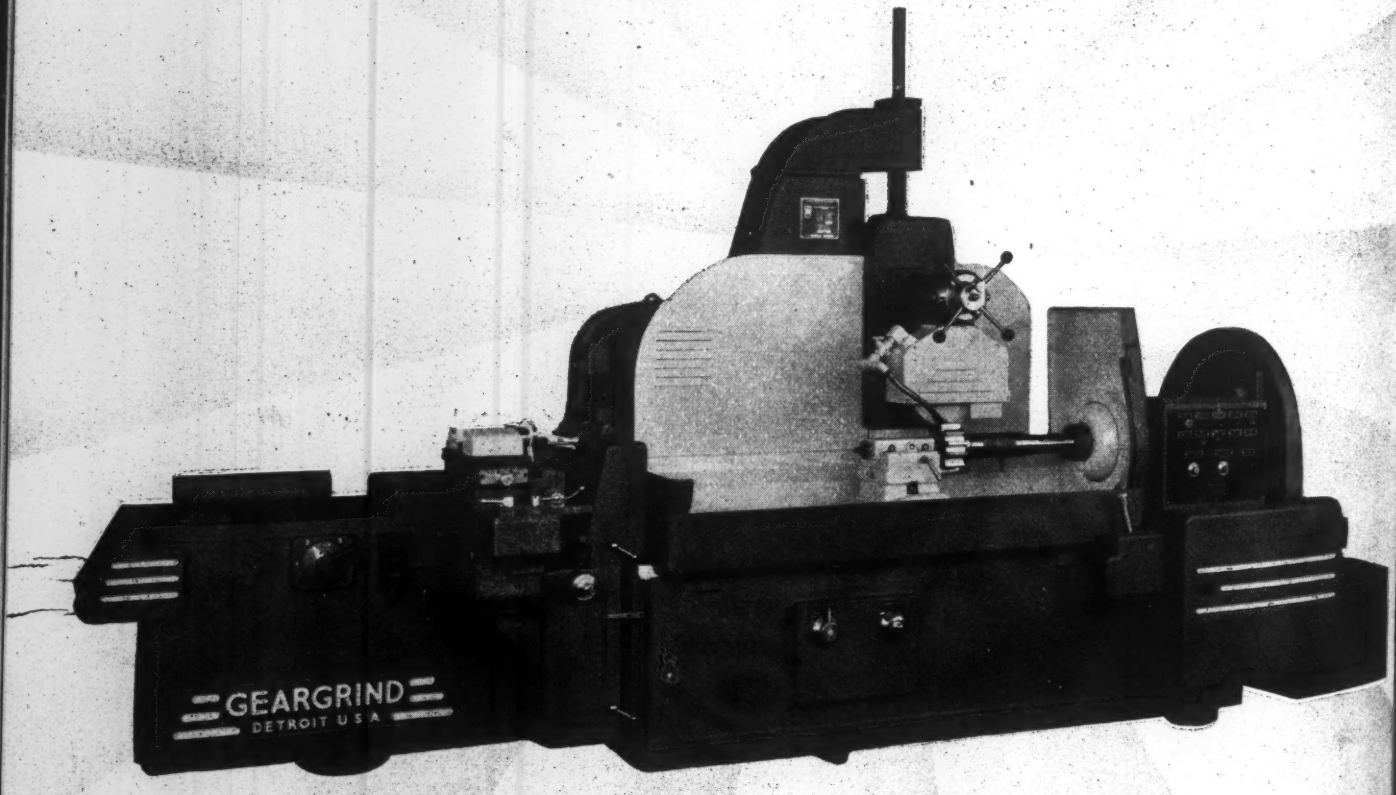
Formed-Wheel Gear Grinder

In this heavy-duty, formed-wheel gear grinding machine, power for both reciprocating the grinding wheel carriage and driving the indexing mechanism is supplied from a single interlocked hydraulic system. The grinding wheel carriage is held stationary during the indexing cycle. An interlocked hydraulic and electrical system assures that indexing is complete before the grinding wheel traverses into the cut.

Designed and manufactured by Gear Grinding Machine Co., this machine employs an index mechanism consisting of a worm drive and change gears driven by a fluid motor. Double indexing (indexing on both sides of the gear) where clearances permit, makes possible a saving of about twenty per cent in grinding time on a typical gear. Automatic trim positioning also is provided. The grinding wheel carriage travels to the dressing position automatically after having completed a preset grinding cycle.

All control levers and pushbuttons are within easy reach and require only light operating forces. Hydraulic piping, valves and pump are mounted on the rear wall of the machine under a removable cover, making for easy maintenance. Rigid construction is maintained throughout the design in order to assure accuracy and good finish.

Work areas are painted light buff. This gives the work better visual definition and as a result curtails operator fatigue, adds to the operator's safety, and makes possible easier inspection.



Hydraulic Bench-Type Press

Direct-drive electric motors are mounted vertically in the column of this bench-type press to furnish power for the hydraulic mechanism. While the normal speed of the ram is 30 feet per minute, it can be adjusted to any value below this by means of an accessory control. In addition, stroke of the ram is easily altered by changing the positions of the stop collars.

Platen is counterbored concentric with the ram, making possible ready location and installation of fixtures in line with the ram movement. Base below the platen is slotted and relieved to permit use of the press for assembly work. Ample stroke is provided so that fairly large work can be handled. For pull-broaching operations, the platen is bored and provided with long guide bushings.

Equipped with a variable-pressure control, the press will handle sensitive assembly jobs with minimum chance of damage to parts. It is manufactured by Colonial Broach Co.

(New machines listing on Page 218)

Design Roundup

Life Increased Twelve Times

RUBBER-COVERED gears for pumps in the cooling systems of barges have solved a serious problem of wear. Previously, metal gears were ruined when the barges ran onto a beach and sucked sand into the pumping system. The sand bites into the teeth of the metal gears and quickly destroys their surfaces. With the rubber-faced gears the sand passes through with little damage to them. Manufactured by the St. Mary's Manufacturing Co. these gears have increased life twelve times over that of metal ones.

In making the gears a brass core is coated with adhesive and placed in the mold. Rubber is then admitted under hydraulic pressure which completes the bonding of the rubber to the core and shapes the outer surfaces of the gear. After removal from the mold, the rubber faces of the gear are machined and ground.

Jet Propulsion Simplifies Problems

FULL THRUST from gas turbines for jet-propelled planes is available in approximately 30 seconds after starting, thereby eliminating any delay in warming up the engines. According to General Electric engineers the turbines operate satisfactorily on either kerosene or gasoline, the former fuel having less tendency than gasoline to ignite in the open air. Because continuous ignition is not required, radio interference and high-altitude ignition problems are eliminated. Thrust produced by the turbine is easily regulated and overhauls may be accomplished quickly when necessary.

Protects Against Corrosion

FILMS OF POLYTHENE applied by flame-spraying methods are tough and highly impermeable and, when applied over metal surfaces, provide a high degree of protection against brines, chemicals and other corrosive agents. In coating by flame spraying, particles of finely ground material pass through a flame and are either softened on the surface or completely melted before they come in contact with the article to be coated. Successive particles impinge on those previously deposited before the particles solidify and thus continuous coatings are obtained. Films applied in this way are so free from even microscopic holes that the use of a Tesla coil shows them to be entirely nonporous. Such coatings may be deposited not only on metals but also on wood, glass, plastics and even paper. Coatings on steel showed excellent adhesion after nine months' immersion in brine with substantially no corrosion of the underlying metal.

Makes Close-Tolerance Parts

TOLERANCE LIMITS for small rubber gaskets are held within .003-inch by an ingenious grinding machine developed by Goodyear. This machine not only grinds the gaskets but handles them in an unusual way. A long tube, loaded with gaskets, is moved across the surface of the machine by cam action. When the tube is directly over the chuck a pump creates a partial vacuum and holds the bottom gasket tightly in the chuck while the tube moves away and the grinding wheel moves into place. When the grinding is finished the wheel moves away and a valve, operated by a solenoid switch, admits a puff of air into the chuck. This blows the gasket out of the chuck and into a basket arranged to catch it. The loading tube then moves over the chuck again and the cycle is repeated at the rate of six gaskets a minute.

Sees Wider Use of Carbon Steels

SUBSTITUTION of induction surface-hardened 1045 steel for many high-alloy steels is foreseen by Wm. C. Dunn of the Ohio Crankshaft Co. "Wearing qualities of the carbon steel so hardened outlast the alloy piece. The classic example is that of a large tractor manufacturer. In the largest unit made by this company, the 28-inch by 5-inch face of the drive gear was formerly a high-nickel alloy. By adopting induction hardening and 1045 carbon steel it was possible to eliminate 13 pounds of nickel per gear and to increase the life of the gear from 100 hours at full load to 3000 hours under the same conditions. In dynamometer tests the carbon-steel gear actually outwore the nickel-molybdenum SAE 4820 mating pinion."

Selecting Surface Quality for Machined Parts

By James A. Broadston
North American Aviation Inc.

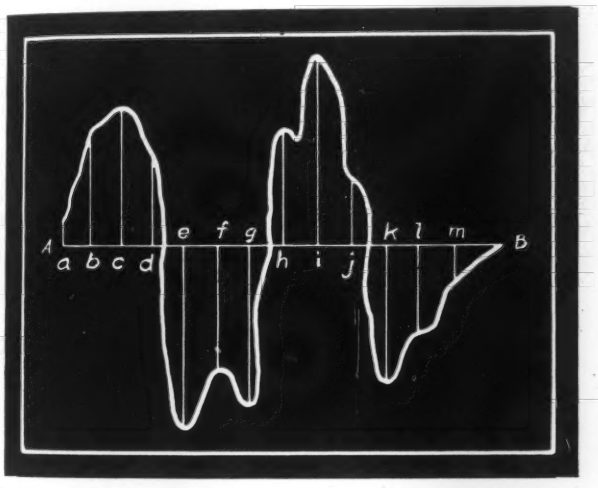


Fig. 1—How root-mean-square value can be calculate l

SELECTION of roughness numbers to indicate the required surface finish of a part must be made with full consideration given to all factors such as the function of the part, the degree of strength it must have, etc. This Data Sheet is presented for the guidance of designers in selecting and specifying roughness numbers for satisfactory performance with minimum cost.

The index to the degree or magnitude of the surface roughness is the RMS micro-inch value which has been chosen by the standards associations and is now generally accepted. RMS micro-inch value is defined as the root mean square (square root of the mean square) of an infinite series of distances measured in micro-inches from the hypothetical nominal or mean surface line to the actual irregular surface contour. For all practical purposes it is a weighted average unit of surface roughness that is affected to a greater extent by the highest and lowest deviation from the nominal surface than it is by the minor variations. Micro-inches are millionths of an inch (.000001-inch) and have been selected as the universal unit of surface roughness measurement because the values of ordinary machined surfaces can be expressed so perfectly by simple whole numbers.

The RMS micro-inch roughness value can best be explained by the use of a sample calculation. Assuming that the wavy line *A-B* in *Fig.* 1 represents a very short portion of the actual section contour of a machined surface greatly magnified, the RMS value is determined by first drawing a mean or nominal surface line for reference. This straight line is positioned

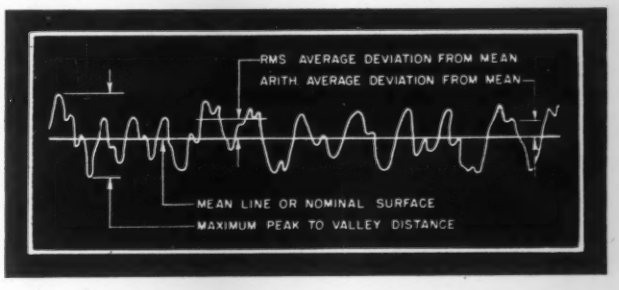


Fig. 2—Arithmetic and root-mean-square values compared with actual surface roughness

parallel to the plane of the surface being measured and at such a depth that the areas between it and the wavy surface contour line are equal above and below. It represents the perfectly smooth surface that would result if all the material in the peaks were used to fill all the valleys. The mean line is then divided into a series of equal divisions; the more divisions taken the more nearly perfect will be the result. From each of these points such as *a*, *b*, *c*, etc., *Fig.* 1, a measurement is made and tabulated. Each value measured is squared and the square root of the average or mean square (determined by adding the values and dividing them by the number of measurements taken) is the RMS value of roughness of the surface.

Comparison of the RMS value and the arithmetical

Engineering Data Sheet

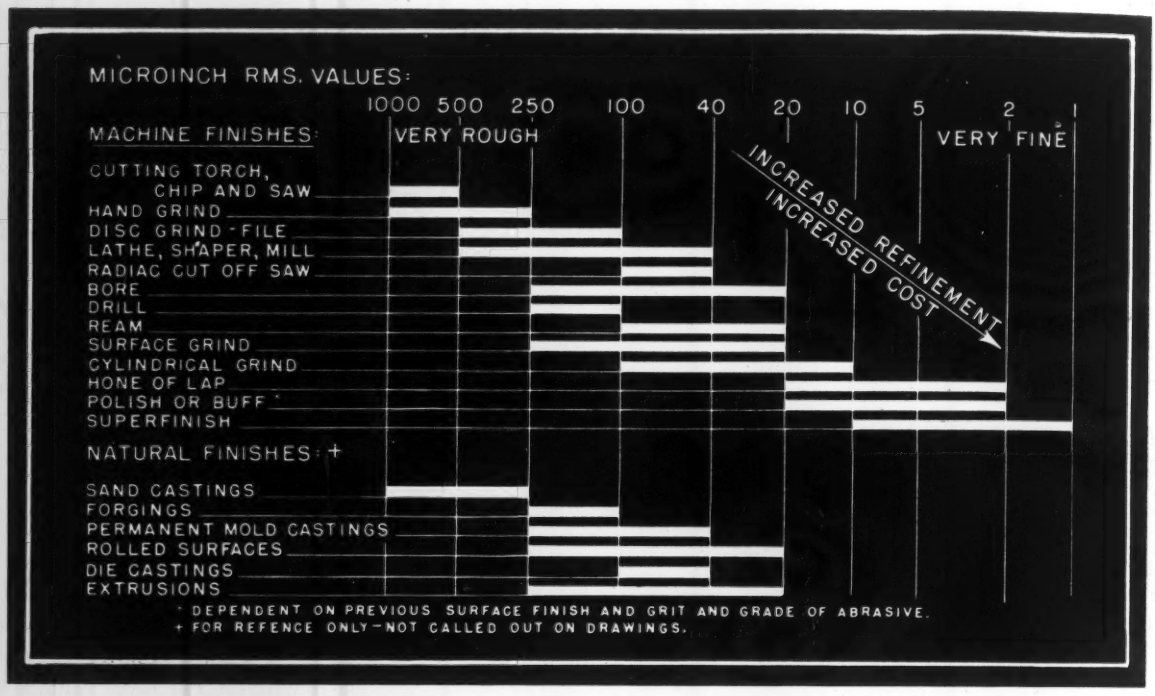


Fig. 3—Above—Surface roughnesses to be expected from various machine and natural finishes

average, *Fig.* 2, shows how closely these values correspond. In fact, they are so nearly the same that either lies within the accepted tolerances of measurement. Inasmuch as early tracer-point surface analyzers indicated an RMS value only, this was chosen as standard.

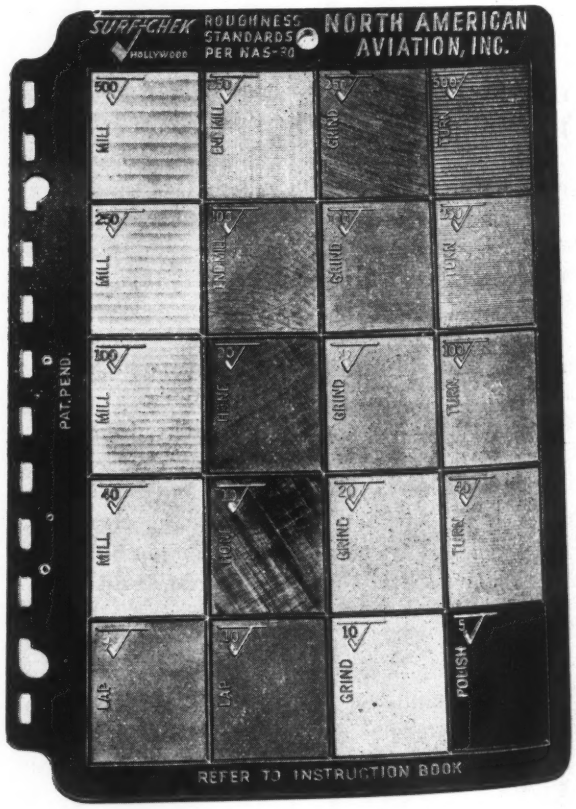
The National Aircraft Standards Committee has set up the NAS-30 standard roughness numbers for aircraft finishes covering normal airplane manufacturing requirements. These standards, indicating RMS microinches maximum allowable roughness, are limited to the following preferred numbers: 500, 250, 100, 40, 20, 10, 5, 2, and 1. In the accompanying tables these surfaces, with the exception of 2 and 1, are described and additional data given regarding the production of these surfaces and their application to aircraft parts. *Fig.* 3 indicates the results of measurements made to determine the nominal surface roughness to be expected of each type of machine finish.

From an inspection standpoint the preferred roughness numbers may be divided into two groups:

Noncritical Range 500 and 250: Specified only when it is necessary to remove metal in order to size a part quickly and where the surface finish is relatively unimportant.

Critical Range 100, 40, 20, 10 and 5: These surfaces are made smoother than normal rapid machining operations would produce. Finish compliance is very important. Any surface with a roughness of 20 or less is quite sensitive to imperfections and should be perfectly free from tool marks, scores, scratches, or any other type of flaw in order to function properly.

Fig. 4—Below—Plastic gage for comparing surface roughnesses by feel, as with a finger nail



Comparison of surface quality can be made by sight, feel or instrument. However, visual inspection cannot be depended upon. The prevalent idea that the brighter a surface appears the smoother it is finished is definitely a misconception. It is very possible that a curved steel cylinder with RMS value 250 micro-inches or more will shine brightly while a ground and lapped valve with a finish of about 5 micro-inches will be gray, dull and lusterless.

The complicated and highly expensive instruments necessary for accurate measurement of surface roughness cannot be set up all over a plant for routine inspection. Further, roughness standards are nothing more than limiting values—they do not represent requirements for duplicating roughnesses. For example, if a drawing calls for a 40 RMS micro-inch finish on a machine part, what has been specified is this: The parts must have a 40 RMS micro-inch roughness *or smoother*. There is considerable leeway below the 40 value called for but none above. Hence, a comparison through touch which will indicate quite definitely whether a surface is smoother or rougher than the standard is satisfactory for routine inspection. Except for extremely fine surfaces, less than 5 micro-inches differences in roughness are made apparent by merely scraping the fingernail over the two surfaces.

Comparing Roughnesses

To provide a practical standard of comparison which can be duplicated and widely distributed throughout a plant, North American Aviation employs the "Surf-Chek" roughness standard shown in *Fig.* 4. This is a simple surface roughness comparison gage made of a phenol-formaldehyde molding compound. Twenty surfaces of varying degrees of roughness conforming to the standard values designated by the National Aircraft Standards Committee are molded into the 5 by 7-inch plastic plate through the use of precise die inserts. Inasmuch as the Surf-Chek is made of black plastic, the surfaces do not present a metallic surface as do most other roughness specimens; consequently, there is less possibility of being misled by surface color, brilliance or hue when making a roughness comparison.

500 Micro-Inch RMS Surface

Description: A very rough, low-grade machine surface that results from heavy cuts and coarse feeds in milling, turning, shaping, and boring as well as from very rough filing, rough disk grinding, and snagging.

Applications: May be used on secondary parts which are not subject to vibration, fatigue, or stress concentration, and whose failure would not endanger the safety of the airplane. Seldom used for aircraft parts, but quite suitable for clearance surfaces on jigs and fixtures.

250 Micro-Inch RMS Surface

Description: Definitely shows tool marks resulting from a rapid feed in producing a medium machine finish. May be produced by a very coarse surface grind, a rough file, a smooth disk grind, a coarse emery buff, and similar operations. Scratches caused by chips will not be cause for rejection, unless excessive in size and number.

Applications: By far the most popular for general use. Normally specified for all aircraft applications where stress requirements, appearance, and conditions of operation and design permit. May be used as a rough finish for aluminum and other soft alloys, and as a surface for cut extrusions such as clips, braces, etc. Used on steel and hard alloys where moderate notch sensitivity exists, but where a rough finish is otherwise tolerable. Used for surfaces under moderate tension, and for the external portions of landing gear parts and hydraulic struts. Also may be used on interior parts where an average machine finish is acceptable, on structural parts having normal margins of safety that are not critical in fatigue, and on very deep bores that do not require a special finish for functional purposes.

100 Micro-Inch RMS Surface

Description: Smooth machine finish. Requires high grade machine work in which relatively high speeds and fine feeds are used in taking relatively light cuts with well-sharpened cutters. All methods of direct machining will produce this surface under proper conditions, including coarse surface and cylindrical grinding, smooth disk grinding, and smooth hand filing.

Applications: Suitable for use on main structural fittings and machined terminals subject to flight loads and vibration, such as wing and tail surface fittings, control fittings, control surface parts, etc. May be used on highly stressed parts of the primary structure whose failure would endanger the airplane. It is the coarsest finish allowable for bearing surfaces, and may be used only where motion is slow and loads are light or infrequent. Also used where close fits are required, such as for internal machined parts, and may be used for all stressed parts except rotating shafts, axles, and parts subject to severe vibration or extreme tension. Is also adequate for short inside bores

on highly stressed parts subject to vibration or flight loads, and for structural parts cut from extrusions or from sheet over .25-inch thick.

40 Micro-Inch RMS Surface

Description: Corresponds to a very fine machine finish, a carbide or diamond bore, a medium surface and cylindrical grind, a rough emery buff, and a ream, burnish, or similar operation. In the case of turned parts, is usually obtained by removing fine tool marks by subsequent hand work with fine emery cloth. On flat parts an equivalent surface may be produced by a power sanding machine using a fine grit belt.

Cost: When specifying a surface of 40 micro-inch RMS or finer, careful consideration must be given to increased shop costs.

Applications: Used where stress concentration is high, or on external surfaces of cylindrical parts that are highly stressed by flight loads or subject to vibration. Difficult to produce by lathe, mill, or other machining operation, but relatively easy to produce by centerless, cylindrical or surface grinding. Highly suitable for hardened steel and may be used for bearings where motion is not continuous and loads are light, providing the lay (direction of the predominant tool marks or pattern of the surface roughness) is in the direction of motion. If required, may be used on all stressed parts except extreme tension members such as engine mount bolts.

20 Micro-Inch RMS Surface

Description: Produced by a fine cylindrical grind, very smooth ream, fine surface grind, smooth emery buff, coarse hone, or a coarse lap.

Applications: Seldom used except where surface is of primary importance for proper functioning of the part. Typical applications: Rapidly rotating shaft bearings, heavily loaded bearings, and extreme tension members. Is the finish required for bottoms of static sealing ring grooves, and similar applications.

10 Micro-Inch RMS Surface

Description: Produced by the finest cylindrical grinding, microhoning, honing, lapping, or buffing.

Applications: Should be specified only where coarser finishes are definitely known to be inadequate. The interior honed surfaces of hydraulic cylinders are an example.

Comparison: The appearance of surfaces of 10 RMS or finer is not a dependable way to judge their quality, as these finishes may either be bright or dull depending upon the method used to produce them. Accurate comparison of fine finishes requires either "feel" or the use of roughness measuring instruments.

Cost: In many cases the additional cost of finely finished surfaces is due to the fact that processes suitable for preparing fine surfaces are notoriously poor for removing material. The 10 RMS grind, for example, is just about as fine a grind as is commercially suitable for a sizing operation. To produce a finer grind, or equally fine surfaces by other means, requires that the parts be sized prior to the finishing operation.

5 Micro-Inch RMS Surface

Description: Normally produced by honing, lapping, Superfinishing, very fine buffing, or bright polishing.

Applications: Required only where packings and rings must slide across the direction of the surface grain and lubrication is not dependable, such as on chrome plated piston rods.

Materials Work Sheet

Magnesium Casting Alloys

ASTM No. B80-41T, Alloys 2, 3, 4, 4X, 11, 17 and 17X
B94-40T, Alloys 12 and 13

AVAILABLE IN:

(B80-41T) All alloys available in ingots for sand and permanent-mold castings. Also available as castings made to specifications

(B94-40T) Both alloys available in ingots for die casting and as die-cast parts made to specifications

ANALYSES:

Alloy No.	Aluminum (range)	Manganese (min.)	Zinc (range)	Silicon (max)	Copper (max)	Nickel (max)	Iron (max)	Magnesium (range)
B80-41T, 2	9.0 to 11.0	.10	.3 max	.3	.05	.03	....	*
3	11.2 to 12.8	.10	.3 max	.3	.05	.03	....	*
4	5.3 to 6.7	.15	2.5 to 3.5	.3	.05	.03	....	*
4X†	5.3 to 6.7	.15	2.5 to 3.5	.3	.05	.005	.005	*
11	.....	1.20	.....	.3	.05	.03	....	*
17	8.3 to 9.7	.10	1.6 to 2.4	.3	.05	.03	....	*
17X†	8.3 to 9.7	.10	1.6 to 2.4	.3	.05	.005	.005	*
B94-40T,12	9.0 to 11.0	.10	.3 max	1.0	.05	.03	....	*
13	8.3 to 9.7	.10	.4 to 1.0	.5	.05	.03	....	*

*Balance is magnesium plus normal impurities not in excess of .3 per cent.
†Alloys 4X and 17X are the same as Alloys 4 and 17 respectively except that iron and nickel contents are held to low values to obtain maximum resistance to salt water corrosion. Resistance to normal atmospheric corrosion is not materially increased. Mechanical properties are identical to those of Alloys 4 and 17.

PROPERTIES

ULTIMATE TENSILE STRENGTH

(1000 *psi*)

	B80-41T					B94-40T	
	2	3	4	11	17	12	13
As cast (typical)	20	19	27	14	23	32	34
(minimum)	18	17	24	12	20	..	..
Heat treated (typical)	35	..	37	..	39	..	..
(minimum)	29	..	32	..	32	..	..
Heat treated and partially aged (typical)	35	..	..	..	..	..	..
(minimum)	29	..	..	..	..	..	..
Heat treated and fully aged (typical)	36	32	36	..	38	..	..
(minimum)	29	27	34	..	34	..	..

TENSILE YIELD STRENGTH

(.2% *offset*, 1000 *psi*)

	B80-41T					B94-40T	
	2	3	4	11	17	12	13
As cast (typical)	11	14	11	4.5	14	22	22
(minimum)	10	11	10	4.0	10	..	..
Heat treated (typical)	12	..	12	..	14	..	..
(minimum)	10	..	10	..	10	..	..
Heat treated and partially aged (typical)	16	..	..	..	..	..	..
(minimum)	15	..	..	..	..	..	..
Heat treated and fully aged (typical)	19	20	18	..	20	..	..
(minimum)	17	17	16	..	18	..	..

MACHINE DESIGN is pleased to acknowledge the collaboration of American Magnesium Corp. in this presentation.

Materials Work Sheet

ELONGATION

(per cent in 2 inches)

	B80-41T					B94-40T	
	2	3	4	11	17	12	13
As cast (typical)	2	.5	6	5	1	1.5	3
(minimum)	1	none	4	3	none	..	..
Heat treated (typical)	9	..	9	..	10	..	..
(minimum)	6	..	7	..	6	..	..
Heat treated and partially aged (typical)	4	..	..	..	..	..	..
(minimum)	2	..	..	..	..	..	..
Heat treated and fully aged (typical)	1	.5	4	..	3	..	..
(minimum)	none	none	3	..	1	..	..

FATIGUE ENDURANCE LIMIT

(typical—500 million reversals—1000 psi)

	B80-41T					B94-40T	
	2	3	4	11	17	12	13
As cast	8	6	11	..	12	13.5	14
Heat treated	11	..	11	..	12	..	..
Heat treated and partially aged	8	..	..	..	..	..	..
Heat treated and fully aged	8	7	9	..	12	..	..

SHEAR STRENGTH

(typical, 1000 psi)

	B80-41T					B94-40T	
	2	3	4	11	17	12	13
As cast	18	17	18	11	18	..	..
Heat treated	20	..	18	..	20	..	..
Heat treated and partially aged	21	..	..	..	..	..	..
Heat treated and fully aged	22	19	20	..	22	..	..

PROPERTIES AT ELEVATED TEMPERATURES

ASTM No. B80-41T	Testing Temperature (deg F)	Days at Testing Temperature	Tensile Strength (psi)	Yield Strength (psi)	Elongation (per cent in 2 inches)
Alloy No. 2 Heat treated	75	0	32,000	13,700	8.2
	150	80	35,000	.....	2.0
	200	160	34,000	.....	1.5
	250	160	28,900	.....	3.0
	300	160	23,300	.....	9.0
	500	1	12,500	.....	22.5
Alloy No. 2 Heat treated and fully aged	75	0	36,800	18,300	1.5
	300	151	22,500	10,600	26.0
	400	254	15,400	7,300	46.0
	500	122	11,000	4,800	46.0
Alloy No. 3 As cast	75	0	20,700	12,500	.5
	300	151	19,000	9,500	2.5
	400	93	17,600	8,000	5.0
	500	84	12,800	5,400	19.0
Alloy No. 3 Heat treated and partially aged	75	0	32,000	22,600	.5
	100	1	32,000	.....	.5
	200	1	29,000	.....	.5
	300	1	25,700	.....	2.5
	500	1	13,600	.....	14.0
Alloy No. 4 As cast	75	0	28,600	13,700	4.5
	150	80	30,500	.....	3.0
	200	160	30,100	.....	4.5
	250	160	27,700	.....	7.5
	300	160	24,100	.....	20.5
	400	160	15,300	.....	50.0
	500	160	10,300	.....	38.0
Alloy No. 4 Heat treated	75	0	36,200	13,600	8.5
	150	80	34,800	.....	6.0
	200	160	34,300	.....	7.0
	250	160	30,000	.....	9.0
	300	160	22,400	.....	33.2
	400	160	14,600	.....	35.5
	500	160	10,900	.....	26.0

BRINELL HARDNESS

(500 kg load, 10 mm ball—typical)

	B80-41T					B94-40T	
	2	3	4	11	17	12	13
As cast	52	65	51	33	65	63	60
Heat treated	52	..	51	..	63	..	..
Heat treated and partially aged	60	..	..	..	..	..	..
Heat treated and fully aged	69	85	69	..	78	..	..

CHARPY IMPACT

(keyhole notch, ft lb.)

	B80-41T					B94-40T	
	2	3	4	11	17	12	13
As cast	.6	.4	1.0	3.0	.5	..	..
Heat treated	2.0	..	2.5	..	2.0	..	..
Heat treated and partially aged	1.0	..	..	..	..	..	..
Heat treated and fully aged	.7	.5	1.1	..	.8	..	..

PROPERTIES AT ROOM TEMPERATURE AFTER PROLONGED HEATING AT ELEVATED TEMPERATURES

ASTM No. B80-41T	Heating Temperature (deg. F)	Days at Heating Temperature	Tensile Strength (psi)	Yield Strength (psi)	Elongation (per cent in 2 inches)	Brinell Hardness[1]
Alloy No. 2 Heat treated	75	0	32,000	13,700	8.2	55
	200	160	36,200	23,000	1.0	86
	250	160	35,100	24,500	1.0	84
	300	160	35,600	20,700	1.3	82
Alloy No. 2 Heat treated and fully aged	75	0	36,800	18,300	1.5	81
	300	151	33,400	16,000	1.5	79
	400	254	31,000	13,400	1.5	73
	500	122	28,700	11,200	4.4	65
	600	129	27,400	10,400	4.8	58
	700	73	26,500	10,300	5.0	57
Alloy No. 3 As cast	75	0	20,700	12,500	.5	65
	300	151	20,700	12,500	.8	74
	400	93	20,700	12,500	1.0	75
	500	84	20,600	12,500	1.1	70
Alloy No. 4 As cast	75	0	28,600	13,700	4.5	52
	200	160	31,300	.....	2.0	72
	250	160	30,800	19,950	1.5	72
	300	160	32,500	19,700	1.8	73
	400	160	34,000	20,300	4.0	62
	500	160	24,500	14,300	3.0	54
Alloy No. 4 Heat treated	75	0	36,200	13,600	8.5	54
	200	160	38,000	.....	6.0	67
	250	160	39,700	23,700	2.5	77
	300	160	34,800	19,800	2.0	73
	400	160	32,700	20,600	3.0	64
	500	160	30,000	14,000	4.5	55

[1]Brinell hardness numbers were obtained with 500-kilogram load, 10-millimeter ball.

CHARACTERISTICS

Magnesium is the lightest of the structural metals, has a high strength-weight ratio and excellent machining properties. Where parts are subjected to abrasive wear, the surfaces affected should be protected by a harder metal, leather, fiber, rubber or similar material, depending on the nature of the application. For maximum corrosion resistance, suitable protective coatings must be utilized. Magnesium should not be used in direct contact with such metals as tin, copper, brass, bronze, monel, cast iron or steel in the presence of moisture, as the galvanic couple resulting will accelerate corrosion of the magnesium.

At the present time, Alloys 17 and 4 are used mostly for sand castings. Other compositions are employed for special purposes. Alloy 17 has better casting (foundry) characteristics and is less subject to microshrinkage than Alloy 4. However, where greatest toughness or resistance to shock is desired, Alloy 4, heat treated, is best. Alloy 3, in the heat treated and artificially aged condition, possesses the greatest hardness of the present known magnesium casting alloys. Magnesium sand castings are not affected by so-called "skin-hardness", indicating that their strength is not lowered by removing the outer skin during machining. Grain size of cast magnesium structures can be controlled closely.

In service, all incompletely aged magnesium alloy castings, except those of Alloy 11, show susceptibility to slight permanent growth, of such small order, however, as to be of little

practical consequence in most applications. Mechanical properties of cast magnesium alloys are practically unaffected by exposure to subnormal temperatures as low as —112 degrees Fahr. At elevated temperatures (as is shown in accompanying charts) all magnesium alloys soften and lose strength. Magnesium alloy castings are sound and entirely free of the defect known as "pinhole porosity".

APPLICATIONS

B80-41T, Alloy 2: For permanent-mold castings. In the as-cast form, this alloy is recommended for low-stressed parts. When heat treated it is used for castings requiring high strength and leakproofness. In the heat treated and partially aged state it offers high yield strength, and when heat treated and fully aged it is used where high yield strength is of greater importance than elongation.

B80-41T, Alloy 3: For sand castings. As cast, it is recommended for low-stressed castings of thin section. When heat treated and fully aged it is employed for parts requiring high hardness and yield strength, but low elongation.

B80-41T, Alloy 4 and 4X: For sand castings. Where parts of moderate strength are required, this alloy is used in the as-cast condition. Where high tensile strength and ductility is demanded, parts are heat treated. When heat treated and aged, the alloy is suitable for parts requiring high tensile strength and moderate yield strength.

B80-41T, Alloy 11: For sand castings. In the as-cast form it is recommended for low stressed parts requiring good stability and welding characteristics.

B80-41T, Alloy 17 and 17X: For sand and permanent-mold castings. Where parts of good sound structure and leakproofness are needed, this alloy is suitable in the as-cast state. When heat treated, it is recommended for parts requiring high strength, ductility and resistance to leakage. In the heat treated and aged state, it is used where high tensile strength, good yield strength and resistance to leakage are required.

B94-40T, Alloy 12: For die castings of very thin sections and for those which have tendency to crack in the die when cast in Alloy 13.

B94-40T, Alloy 13: General purpose die-casting alloy.

FABRICATION

SAND CASTING:

Foundry equipment designed for aluminum castings can, in the majority of cases, be used satisfactorily for magnesium. Occasionally, however, minor alterations may be necessary. One of the most frequently required changes is an increase in thickness of thin sections because the fluidity of magnesium casting alloys is not as great as that of most aluminum casting alloys. Unless the area of the thin section is quite small or is particularly well placed in the casting to allow easy access to the gates, sections in magnesium casting alloys should not be less than 5/32-inch thick.

When the casting is to be subjected to high stresses in service, it may be deemed advisable to strengthen certain sections, increase the size of stud bosses, and provide more generous fillets at the junctures of all sections. Shrinkage for magnesium casting alloys usually is figured as 5/32-inch per foot under conditions of free shrinkage. Where shrinkage is restrained, it is figured at ⅛-inch per foot. Castings can be supplied with inserts such as bushings, pipes, etc., cast in place. Whenever possible, the insert should be of iron or steel, or, if these materials are not suitable and some nonferrous metal must be used, the nonferrous metal insert must be protected from the alloying action of the molten magnesium. Chromium plating or spraying with iron are the usual methods employed. It gen-

PHYSICAL CONSTANTS

ASTM No. B80-41T	Specific Gravity	Weight (lb per cu in.)	Melting Point (deg F)	Thermal Conductivity (100-300C) C.G.S. Units[1]	Electrical Resistivity at 20 C (68F) (microhms per cu cm)	Electrical Conductivity (% of IACS)
Alloy No. 2						
As cast	1.81	.066	1100	.17	15.0	11.5
Heat treated	1.81	.066	1100	.17	17.5	9.9
Heat treated and fully aged	1.81	.066	1100	.17	14.0	12.3
Alloy No. 3						
As cast	1.82	.066	1075	.16	16.5	10.5
Heat treated and partially aged	1.82	.066	1075	.16	14.0	12.3
Alloy No. 4						
As cast	1.84	.066	1155	.18*	11.5	15.0
Heat treated	1.84	.066	1155	.18*	14.0	12.3
Heat treated and partially aged	1.84	.066	1155	.18*	12.5	13.8
Alloy No. 11						
As cast	1.76	.064	1200	.30*	6.5	26.5
Alloy No. 17						
As cast	1.82	.066	1110	.17*	14.0*	12.3*
Heat treated	1.82	.066	1110	.17*	16.5*	10.5*
Heat treated and partially aged	1.82	.066	1110	.17*	14.0*	12.3*
ASTM No. B94-40T						
Alloy No. 12						
As cast	1.81	.066	1100	.17	15.0	11.5
Alloy No. 13						
As cast	1.81	.066	1120	.17	17.0	10.2

[1]Calories per square centimeter per second per degree Centigrade per centimeter.
*Values are approximate.

NOTES: 1. For all above alloys the mean coefficient of thermal expansion (65-750 F) per degree Fahr. equals .000016 (.000029 per deg C).
2. For all above alloys the mean specific heat (20-350 C) is approximately .27 calories.
3. Modulus of elasticity for all above alloys may be taken as 6,500,000 pounds per square inch.

erally is advisable to select an insert material with a melting point higher than 1200 degrees Fahr. and, if much molten metal must flow around the insert, the melting point of the insert should be above 1400 degrees Fahr.

PERMANENT-MOLD CASTING:

Where quantities justify cost of die equipment, castings made by the permanent-mold method should be considered. Permanent-mold casting produces parts of closer dimensional tolerances, smoother surface finish and denser metal than are possible with sand casting. Parts made by permanent-mold casting generally are less expensive than sand castings when the quantity exceeds 500 to 1000 pieces. Minimum thickness of section which can be cast by the permanent-mold process is approximately ⅛-inch for small areas and 5/32-inch for large areas.

Existing permanent-mold equipment, designed for aluminum casting, often can be used for magnesium but it generally is necessary to alter the method of gating. Alloys 2 and 17 see most general use for permanent-mold casting. Alloy 2, available "as-cast" and in three standard heat treatments, usually is recommended because it has excellent foundry characteristics and good physicals. As permanent-mold cast, it has better corrosion resistance than when sand cast. Although Alloy 17 is somewhat inferior to Alloy 2 in foundry characteristics due to its greater tendency to hot shortness, it is recommended for applications requiring better mechanical properties and greater corrosion resistance than are obtainable with Alloy 2. Permanent-mold magnesium alloy castings generally show a saving in weight and machining as compared with sand castings.

DIE CASTING:

On the average, a quantity of 500 to 1000 castings is sufficient to justify the die cost which is over and above that entailed with sand or permanent-mold casting. Die castings are low in cost, have best dimensional accuracy of all casting processes, offer excellent smoothness of surface, and require either a minimum of machining or none at all. Steel, bronze or brass inserts can be cast in without difficulty.

While both Alloys 12 and 13 are used for die casting, Alloy 13 is used in by far the majority of applications. It offers, in addition to the good foundry characteristics and corrosion resistance of Alloy 12, better mechanical properties. Neither alloy is supplied in any heat treated condition. Generally, magnesium die castings are produced in weights up to about four pounds with maximum dimension in one direction of approximately 24 inches.

Design characteristics applying to aluminum also are applicable to magnesium alloys. Sharp section changes from thick to thin are not conducive to sound castings and should be avoided. Section thickness may run as low as .065-inch on areas of six square inches, and less on smaller areas. Tolerances for magnesium die castings are plus or minus .0015-inch per inch of dimension. On dimensions across die parting line, minimum tolerance is plus or minus .005-inch. On cores and side wall sections, draft generally may be .005 to .01-inch per inch of length. Cores of 3/16-inch or less in diameter and not over ½-inch long may be cast without draft if necessary.

MACHINABILITY:

All magnesium alloys have excellent machining characteristics. Compared with other metals, magnesium allows higher cutting speeds, greater feeds, and deeper cuts. For equal volumes of metal removed, power consumption in machining magnesium is lower than with any other metal. It does not tear or drag and takes a smooth finish. Chips readily clear the work and the tool. Because of their low weight, magnesium parts are easier on the machining equipment and are more quickly handled by the operator. Under many conditions, magnesium alloys may be machined without a lubricant.

Cutting tools have very smooth faces, small areas in contact with the work, and keen cutting edges. Tungsten-carbide tipped tools are recommended for maximum efficiency. Since all magnesium alloys have a low modulus of elasticity, they must be chucked rigidly for machining. Differences in machining characteristics among the various alloys are negligible. To guard against fires, accumulation of chips around the cutting machine is not permitted.

RIVETING:

Magnesium alloys are not used in the form of rivets. Rivets of aluminum alloys with little or no tendency to cause galvanic corrosion of magnesium are preferred. Aluminum alloy 56S in the quarter-hard temper is usually specified for such rivets and requires no heat treatment and quenching prior to driving. Minimum distance between rivet centers should be three times the rivet diameter.

Rivet holes should be drilled and reamed, not punched, and there should be about .015 to .03-inch clearance between hole and rivet shank diameter. Insulation of the rivet from the magnesium structure by zinc chromate primer is recommended to prevent possible corrosion.

FASTENING WITH SCREWS:

Coarse-threaded screws with flat or rounded thread tops such as the American National Coarse Series or the British Standard Whitworth are preferred over the finer thread types. Thread length in the magnesium part should be two to three times the diameter of the screw. To minimize stress concentrations at the roots of threads, threaded-in or cast-in inserts of steel or another wear-resisting metal are recommended. To insure most favorable stress distribution, screws should be more closely spaced than in similar assemblies using ferrous

RATINGS OF MAGNESIUM FABRICATING PROCESSES

(*A*=*Best*)

Process of Fabrication	Weight Saving	Capacity of Producing Intricate Shapes	Dimensional Accuracy	Cost of Finished Part		Strength	Size
				Small Lots	Large Lots		
Sand Casting	E	A	D	A	D	C	A
Permanent-Mold Casting	D	B	C	C	C	C	C
Die Casting	B	C	A	D	A	D	D
Forging	C	E	C	D	B	A	C
Extruded Shapes	B	F	B	B	B	A	B
Tubing	B	F	B	C	B	B	B
Formed Sheet Parts	A	D	C	D	C	B	B

alloys. To hold galvanic corrosion at a minimum, steel screws should be either galvanized or cadmium plated. Under vigorous corroding conditions, screws should be dipped in zinc chromate primer or a joint-sealing compound. Washers aid to distribute stress and should be about 1/3 the hole diameter in thickness, 2½ to 3 times the hole size in diameter. Steel washers, cadmium plated or galvanized, or 56S aluminum alloy are recommended.

WELDING (*general*):

Magnesium casting alloys are welded in the foundry and in fabricated parts. Sand and permanent-mold castings can be fusion welded or electric-resistance welded, but die castings are difficult to weld by any process and are seldom specified when welding is involved. In fusion welding, regardless of alloy or type of weld, preheating to temperatures from 400 to 650 degrees Fahr. is desirable to minimize thermal stress gradients which may cause cracking when parts cool.

FUSION WELDING:

Commercial fusion welding methods applied to sand or permanent mold castings are oxyacetylene welding or helium-arc welding. Metal-arc and carbon-arc welding have been used experimentally with some promise but production experience is not yet available. Helium-arc welding is a useful tool in the foundry to finish local areas where the casting has not completely filled the mold. This welding method can be applied to almost any alloy or casting except to repair cracks which may have appeared in the casting procedure. Both helium-arc welds and oxyacetylene welds are used for welding castings to sheet. Alloy 11 is the most weldable material for such work and is used almost exclusively in oxyacetylene welding. The helium arc, on the other hand, can be used with this and other casting alloys to make sound pressure-tight joints to wrought magnesium products. Details on procedure, flux, and cleaning can be obtained by application to the manufacturer.

RESISTANCE WELDING:

Both sand and permanent mold castings can be spot welded, seam welded, or flash welded to other castings or to wrought products. Spot welding is the most widely used process. Precautions in the way of special tip shapes or tip alloys are sometimes required to compensate for the differences in electrical resistivity that may occur in welding castings to wrought products. Corrosion resistance in spot welds generally is good. Best corrosion resistance is obtained only if the surfaces contacting the welding tip are cleaned mechanically after welding to remove copper which is deposited in the welding operation. Mechanical wire brushing or surface machining of castings is advisable at the welding locations before welding, since the "as cast" surface is difficult to weld because of tip pick-up.

RESISTANCE TO CORROSION

Commercially pure magnesium and many of its alloys resist the action of most outdoor atmospheres rather well, although some surface attack of the uniform-etching type occurs. However, unless moisture is trapped in crevices or low spots, no structurally serious corrosion will occur. Marine or seacoast locations are more corrosively active than inland locations and may cause severe attack. Unless it is known that the environment and conditions of service are not detrimental to magnesium, it is advisable to protect the parts with a painting system which will withstand severe exposure conditions.

Action of solutions of many alkaline materials, borates, fluorides, chromates, chromic acid and hydrofluoric acid is well resisted by magnesium alloys. Solutions of most other mineral acids and of the salts of these acids are definitely corrosive.

GALVANIC CORROSION

In most environments, magnesium has a higher electrolytic solution potential than the other structural metals. Joints of magnesium with most other metals, therefore, require protective insulation under conditions conducive to galvanic corrosion, that is when moisture is present in a joint. Lack of such insulation will result in severe corrosion adjacent to the dissimilar metal. The severity of galvanic corrosion resulting

Insulating materials vary in efficiency and care should be used in their selection. Under conditions of outdoor exposure, a good method is the use of insulating layers of zinc chromate primer or of nondrying sealing compounds. In more severe cases, the use of these materials combined with gaskets is recommended. About the best joint sealers commercially available at present are mixtures of zinc chromate, aluminum powder, inert filler, oils and thinner.

Much can be done in the actual design of the part to make it less susceptible to corrosion. For example, pockets which can catch and retain water, or closed containers without ventilation where water may condense, are to be rigorously avoided. Where such pockets must exist, provision for simple drainage should be made.

MATERIAL DESIGNATIONS

Commodity	A.S.T.M.	A.M.S.	U. S. Army	Army Air Forces	Navy Dept.	Bureau of Aeronautics	Army, Navy Aeronautical	Amer. Mg. Corp.	Dow Chem. Corp.
Sand Castings	B80-41T, Alloy 8	.....	.....	.....	.....	.....	.....	AM-246	D
	B80-41T, Alloy 4	C-4420B T4-4422C T6-4424C	57-74-1E	.....	46-M-12, Gr 4	M-112G, Gr 4	AN-QQ-M-56, Gr A	AM-265	H
	B80-41T, Alloy 11	.....	57-74-1D, Gr 2	.....	46-M-12, Gr 11	M-112G, Gr 11	AN-QQ-M-56, Gr B	AM-268	M
	B80-41T, Alloy 17	T6-4434B	.....	.....	46-M-12, Gr 17	M-112G, Gr 17	AN-QQ-M-56, Gr C	AM-260	C
Permanent-Mold Castings	B80-41T, Alloy 2	.....	.....	11348	.....	.....	.....	AM-240	C
	B80-41T, Alloy 17	T6-4484	57-74-2	11349	.....	.....	.....	AM-260	C
Die Castings	B94-40T, Alloy 12	.....	Air Corps 11319	.....	46-M-11	M-369	AN-M-16	AM-230	I
	B94-40T, Alloy 18	4490A	57-74-8 Air Corps 11319	.....	46-M-11	M-369	AN-M-16	AM-263	I

SLEEVE TYPE BEARINGS
for
Every Type of Industry

For the New Product

One sure way to make a sales leader out of your new product is to build real performance into it. The best way of securing performance is to select the *correct* bearing for each application. The easiest way to select the right bearing is to consult with Johnson Bronze.

We are particularly well fitted to assist you. As we manufacture all types of sleeve-bearings . . . cast bronze . . . babbitt lined . . . sheet metal . . . powdered bronze, we hold no prejudice for any *one* kind. All of our experience, our facilities and our research for more than thirty-five years have been devoted to producing better bearings.

Why not call in a Johnson Engineer now? Permit him to review your applications . . . to make recommendations based on your operating requirements. There is one located near you. There is no obligation.

For Maintenance

The operating schedules of practically all machines during the past five years have been terrific . . . without parallel in our industrial history. Yet most manufacturers believe that the schedules for the postwar period will be even greater. How is your equipment going to meet this demand?

The first thing to check is the bearings. No doubt a good many will have to be replaced. When replacement is necessary —specify Johnson Bronze. We offer you the most complete line on the market . . . over 350 sizes of UNIVERSAL Bronze Bars . . . over 800 sizes of plain cast bronze bearings . . . 250 types of Electric Motor Bearings . . . babbitt and Ledaloyl, self-lubricating bearings. Every item in the line is the highest quality possible.

Call your local Johnson Bronze Distributor or write for Catalogue No. 410.

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All our present production is for Armament

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PROFESSIONAL VIEWPOINTS

MACHINE DESIGN welcomes comments from readers on subjects of interest to designers. Payment will be made for letters and comments published

". . . lubricator not gravity type"

To the Editor:

With reference to your article "Centralized Lubrication Insures Bearing Life", Part II of which appeared in the October issue of MACHINE DESIGN, we find that our Model 50 lubricator has not been correctly described. In the last paragraph in the first column on Page 82, it is stated "An open system, pressure feed is used up to the cup. Gravity then delivers the oil to the bearing through tubing. This necessitates mounting the unit above all the lubrication points served."

This pumping unit is definitely not in the gravity class. Oil is metered and delivered to the receiving cup by the small plunger of the pumping unit, is then taken from the receiving cup by the large or forcing plunger, and delivered to the terminal position. The large plunger is mechanically ported, and delivers oil against resisting pressures of 1000 pounds or more. Further, it is not necessary to mount the lubricator above the lubrication points or feed terminals."

—W. G. COLES, *Chief Engineer*
Madison-Kipp Corp.

MACHINE DESIGN apologizes for its error in the discussion of the particular Madison-Kipp unit shown in the article.—ED.

" . . . fabricating own control panel"

To the Editor:

With reference to the article "Tailor-Made Controls Utilize Standard Component Parts", by D. K. Frost, we are 100 per cent in agreement with Mr. Frost regarding the desirability of the machinery manufacturer fabricating his own control panel. We have followed this practice for a number of years and during the height of our production schedule we used approximately twenty women in our panel assembly department.

In addition to the advantages of flexibility and economy as outlined by Mr. Frost, there is one other outstanding advantage. This has to do with the replacement parts service. We feel that our responsibilities on the electrical apparatus which we use are identical to the responsibilities for our mechanical parts. Unfortunately, where customers specify parts frequently the descriptions are somewhat inadequate. If these parts are for use on a panel which has been assembled by one of the electrical companies, we have found in the past that repeat orders for the same panel will frequently not be identical in that certain of the smaller parts used might be replaced by the manufacturer with more up-to-date equipment. Where we manufacture and assemble the various standard parts on a panel, our records of the component parts are then such that we can readily handle the replacement parts not only for the complete unit, but for parts of these units such as contacts, coils, etc.

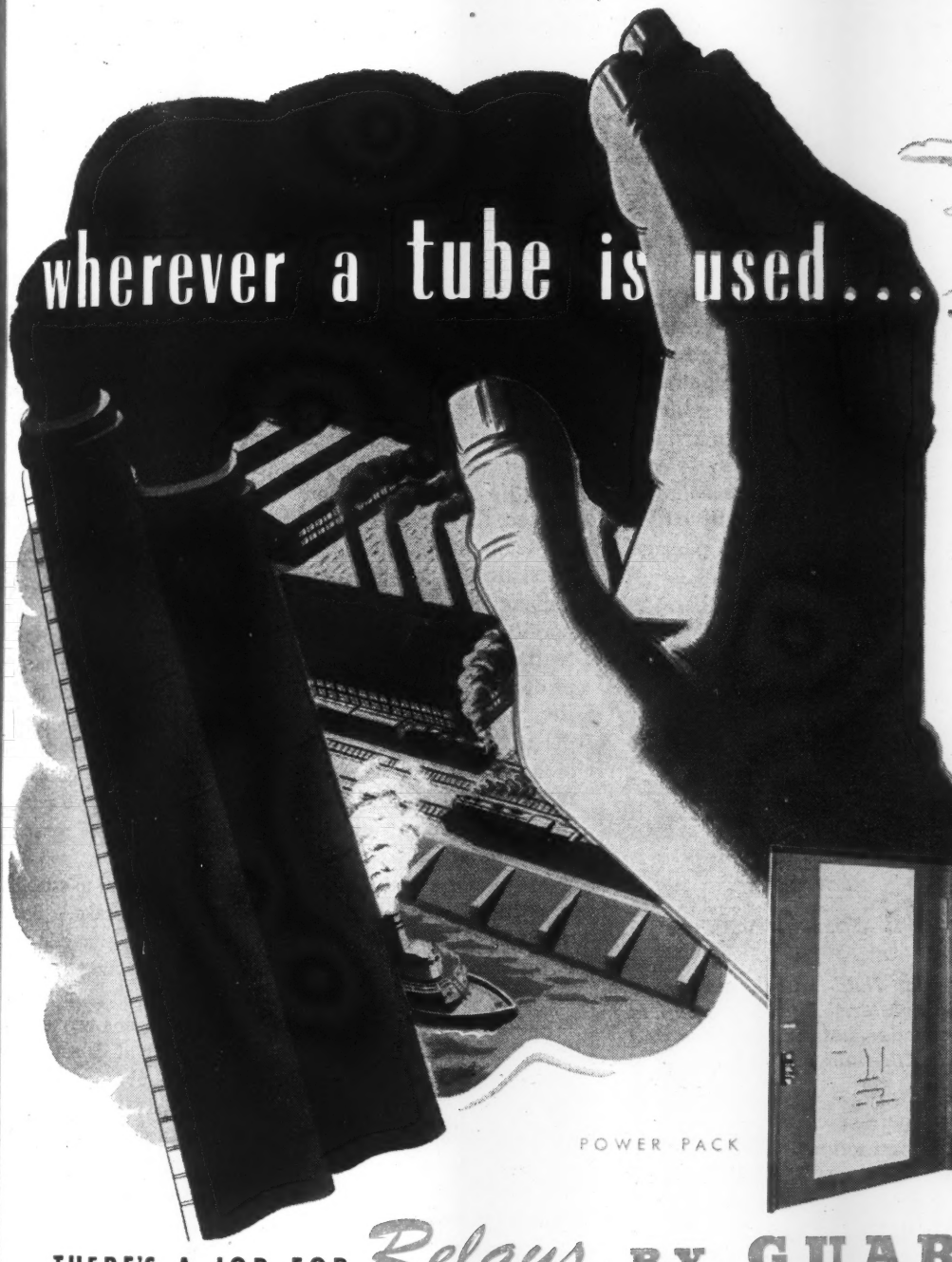
We have adopted one other practice which we believe would be of interest to companies that use their equipment on either 50 or 60 cycle and that is, we use control transformers with a 110-volt secondary tapped at 95 volts. On 50-cycle applications, the standard 110-volt, 60-cycle control coils are used, with the control voltage reduced to 95 volts to compensate for the drop in frequency from 60 to 50 cycles. This enables us to use the standard panels for all power supplies except direct current and 25 cycles.

—A. L. KRAUSE
Brown & Sharpe Mfg. Co.

"We have been hearing a lot about postwar planning. You would think we have never planned before. The thing we must be careful about is to separate the postwar planning from the postwar wishing. If we presuppose that human nature will be different after the war, then we have postwar wishing. Human nature will be the same after the war and there is no use getting sore about that. We will make progress if we are guided by intelligent imagination that stays within the laws of science. Inventions are not overnight flashes of genius, but the products of time and tediousness. We may invent something good for tomorrow or for next year, but probably the most important inventions will be ready for the next generation."—*Dr. Charles F. Kettering*

"The fruits of research, study and experience are not only now helping to win the war, but will very definitely affect the conditions and habits of people in the peacetime era. . . . . Science and technology are destined to shape the future of our affairs."—*G. Edward Dendrow*

wherever a tube is used...

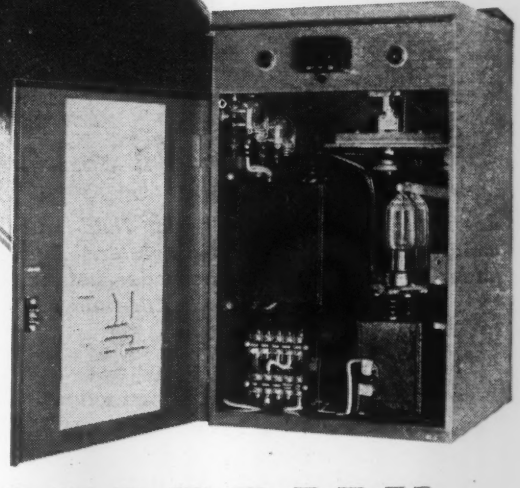


POWER PACK

for example:

ELECTRONIC AIR CLEANING

Smoke, dust, and soot particles 100 times smaller than the eye can see are drawn out of the air electronically by an ingenious arrangement of positively and negatively charged plates. This device facilitates precision manufacturing of delicate instruments, guarantees purity and sanitation in food processing, promotes health and cleanliness in restaurants and hospitals.



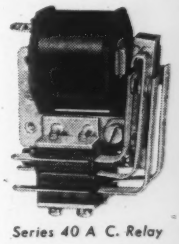
THERE'S A JOB FOR *Relays* BY GUARDIAN

Electronic air cleaners ionize dust particles and collect these particles on a series of positive and negative plates called "Collector Cells" which are arranged in a venetian blind fashion. Rectifier tubes in a power pack change the a-c secondary voltage into pulsating d-c voltage. This d-c voltage is smoothed out by a capacitor and charges the Ionizer and Collector cells.

Relays are built into the power pack to protect it against short circuits or other irregularities in circuit operation. Typical of such relays is the Guardian Series 40 a-c relay which has a laminated armature and field piece.

The Series 40 is well fitted for use in power packs such as illustrated, because it is designed to handle a maximum of control in minimum space. It has a switch capacity of double pole, double throw with 12½ ampere contacts (rated at 110 volts, 60 cycles, non-inductive load). Coils are available for standard voltages up to 220 volts, 60 cycles. Normal power requirements are 9 V. A.

For details on this and other Relays by Guardian write for General Relay Bulletin.



Series 40 A. C. Relay

Consult Guardian whenever a tube is used—however—Relays by Guardian are NOT limited to tube applications but are used wherever automatic control is desired for making, breaking, or changing the characteristics of electrical circuits.

GUARDIAN ELECTRIC

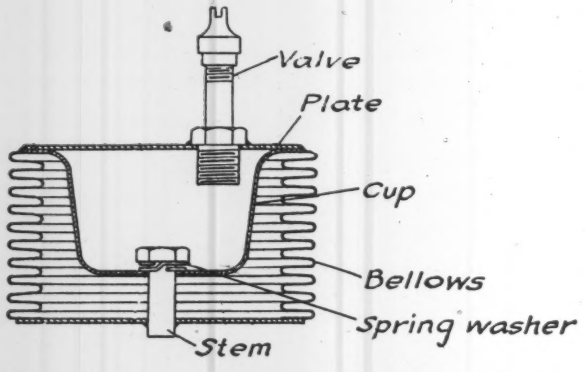
1601-P W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY

Noteworthy Patents

Air Cushions Shock and Vibration

A SHOCK mounting which employs air as the resilient material is covered by patent 2,356,093 recently assigned to Humber Ltd. As shown in the accompanying illustration, the base of the cup is formed with a central hole through which passes a vertical stem which at its lower end extends through and is welded to the lower end plate to limit the extensibility of the bellows. The hole in the bottom of the cup is of sufficiently larger diameter than the stem to provide a restricted passage between the two compartments.



Resilient mounting consists of fluid-tight assembly of metal bellows, cup and end plates. Interior of cup is under compressed air while space between bellows and cup is partially filled with fluid such as oil

The device has elastic properties closely resembling those of rubber. The rate of contraction is controlled by fluid flow between the compartments in the body. With the air in the cup under pressure, the device functions as a compression spring. To make it the equivalent of a tension spring the air may in some cases be initially at atmospheric or lower pressure, this pressure being further reduced when the body is extended.

Transmission Has No Neutral

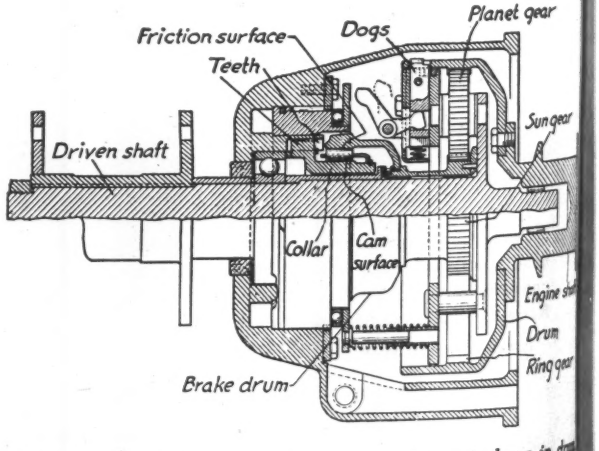
A TWO-SPEED transmission in which the change from one speed to another may be effected without causing the driven shaft to be completely disconnected from the driving shaft for any substantial time interval is covered in patent 2,332,588 recently assigned to Borg-Warner Corp. The transmission has been developed primarily for airplanes with constant-pitch propellers, in which a speed reduction during take-off may be employed to avoid the necessity of providing excessive wing area.

Shown in cross section in the accompanying diagram, the design employs a direct drive for normal flight operation and a planetary reduction drive for take-off. Engine shaft projects into housing of the transmission and is bolted to a drum, a portion of which is formed with internal teeth to constitute a ring gear. Meshing with the ring gear are three planet gears which, in turn, mesh with a centrally located sun gear. Planet gears are mounted upon axles which are supported upon a carrier flange integral with the driven shaft. When the carrier and drum are connected together, a direct drive is effected whereas if the sun gear is held against rotation and the rigid connection between drum and carrier is broken, the driven shaft will rotate at reduced speed.

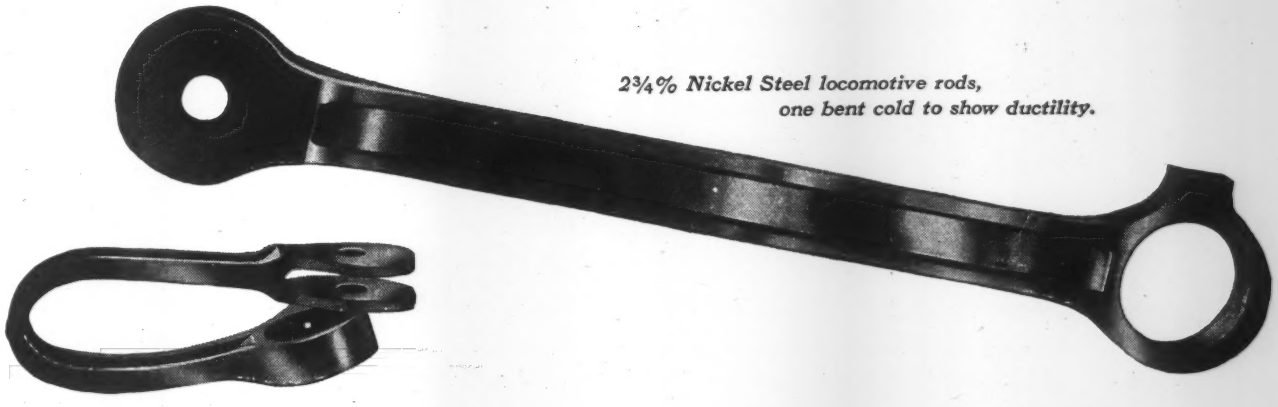
Means for positively locking the drive shaft to the driven shaft consist of radially movable dogs which engage rectangular windows in the drum. The dogs are supported on and rotate with an annular plate which is riveted to the carrier and forms a part of it. They are in the form of rectangular blocks of steel and slide within radial slots. Compression springs urge the dogs into the outward position. In order to prevent the abrupt engagement of a dog with a window the outer surface of each dog is chamfered so that the dog will merely tend to ratchet over the windows until the dogs and windows rotate at the same speed.

Means for arresting the rotation of sun gears to establish a reduced drive consist of a one-way brake. Brake drum is splined to the forward end of the sun gear and is provided with a friction surface surrounding and separated from a collar having a cam surface. Cam surface is similar to that found in a roller type of one-way clutch, the inclination being such that the drum and its connected sun gear cannot rotate reversely with relation to drive shaft, but can rotate in the same direction. Between the cam surfaces and friction surface are located rollers. Forward end of the collar is provided with external gear teeth which mesh with internal teeth formed in an extension of the housing.

To disengage the direct drive clutch, fluid under pressure is admitted to the chamber at the forward end of the piston



Direct drive is through dogs engaging windows in drum, reduced speed drive is through planetary transmission



2¾% Nickel Steel locomotive rods, one bent cold to show ductility.

QUENCHED AND TEMPERED NICKEL STEEL FORGINGS COMBINE EXCEPTIONAL DUCTILITY WITH HIGH TENSILE STRENGTH

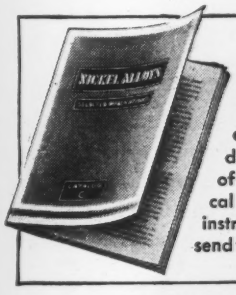
Composition and Typical Properties of Normalized Quenched and Tempered 2¾% Nickel Steel Rods

Description or Size	Melt Yield Pt. No. #s per Sq. In.	Tensile Strength #s per Sq. In.	Elong. % in 2 In.	Reduction in Area %	ANALYSIS					
					Car.	Mang.	Phos.	Sul.	Sil.	Ni
Main Rod....	92900	110000	25.0	64.4	.31	.78	.027	.026	.25	2.75
Main Rod....	86500	104500	25.5	65.6	.32	.86	.034	.032	.29	2.69
Main Rod....	86360	104400	26.0	64.8	.32	.86	.034	.032	.29	2.69
Main Rod....	87850	102350	26.0	66.2	.31	.89	.037	.025	.32	2.69
Front Rod....	86000	102250	25.0	67.3	.29	.82	.035	.027	.24	2.71
Front Rod....	83900	104250	25.0	66.1	.29	.82	.035	.027	.24	2.71
Front Rod....	86850	104250	27.0	66.1	.32	.86	.035	.025	.30	2.65
Front Rod....	89500	107050	25.5	65.6	.32	.86	.035	.025	.30	2.65
Back Rod....	89500	107650	25.0	62.7	.30	.79	.030	.025	.22	2.71
Back Rod....	87500	106450	25.0	65.4	.29	.82	.035	.027	.24	2.71
Back Rod....	87000	105600	25.0	65.4	.29	.82	.035	.027	.24	2.71
Back Rod....	88150	104850	26.0	66.8	.29	.82	.035	.027	.24	2.71

Specimens Taken from Mid-Section of Prolongations of the Forgings

The above table compiled by the American Locomotive Company shows the chemical compositions and mechanical properties of some normalized, quenched and tempered nickel steel front, main and back rods recently produced as replacement rods for locomotives being speeded up and rebalanced. These values are typical of replacement rod forgings recently tested by that company.

Quenched and tempered nickel steel forgings provide high tensile strength and ductility, combined with unusual toughness and high fatigue strength—qualities which tend to obviate breakage and assure long, trouble-free service when employed in heavy duty machinery and equipment.



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* Nickel *

THE INTERNATIONAL NICKEL COMPANY, INC., *67 Wall Street, New York 5, N. Y.*

causing the latter to move to the right. Engagement with the bell crank causes the latter to rotate and withdraw the dogs from the windowed drum, releasing the clutch. When fluid pressure is released the piston is returned to its left-hand position by means of a compression spring.

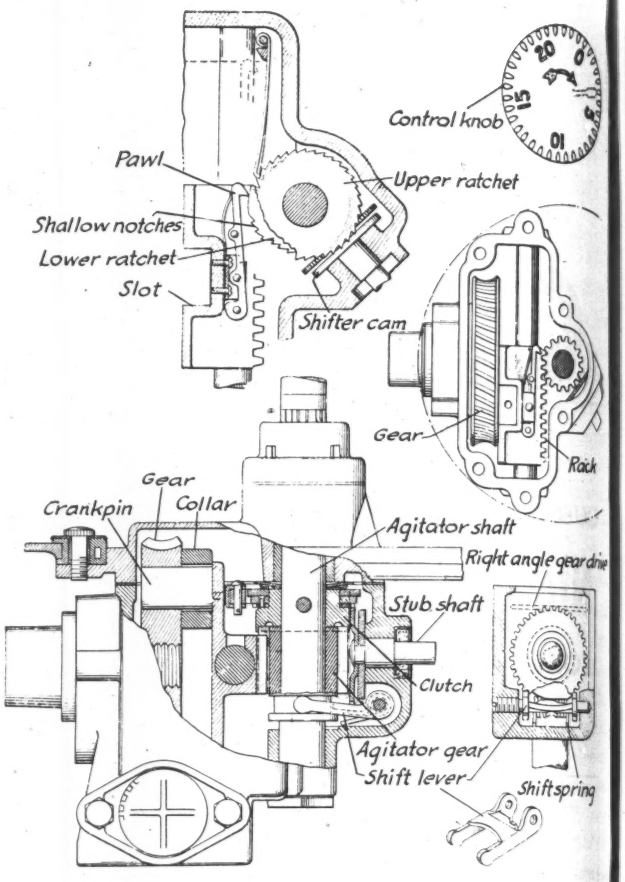
Because of the bell shape of the drum which serves to stop rotation of the sun gear, the radial force exerted by rollers upon the friction surface may tend to expand the drum. This is prevented by providing conical friction surfaces on the drum and on the inside of the piston, providing additional support for the radial thrust and constituting a brake for arresting the rotation of the sun gears. These brake surfaces not only arrest the rotation of the sun gears just prior to the resumption of drive through the reduced ratio but they also perform the important function of taking the coast load of the propeller so that the latter will not be completely disconnected from the engine. The coast load tends to rotate the sun gear in a forward direction off the rollers and if this forward reaction were not taken by friction surfaces the propeller and engine would be disconnected, thus depriving the engine of a flywheel and allowing the propeller to windmill freely.

Mechanical Timing Mechanism

MECHANICAL timing mechanism, designed particularly for incorporation in domestic washing machines, is the subject of patent 2,344,651 recently assigned to The Maytag Co. With such a device the operator can preset the length of time required for washing any particular type of garment, and is relieved of the responsibility of watching the clock for time to stop the machine.

When the machine is set in operation a knob is adjusted to the predetermined time, which may be up to twenty minutes, at the end of which time the clutch on the agitator shaft is disengaged, stopping the movement of the agitator. As shown in the accompanying illustration, the driving mechanism consists of a driven worm wheel provided with an eccentric crank journaled in a collar and sliding in a vertical slot in the rear face of a rack. As the gear rotates, the rack reciprocates in a horizontal plane and imparts oscillating movement to a gear which is concentric with the agitator shaft. The agitator gear operates the agitator through a clutch. Engagement and disengagement of the clutch is effected by a shifter lever at the lower end of the agitator shaft. The control knob, which is conveniently located on the outside of the machine, is connected through a system of shafts and universal joints to the stub shaft shown in the illustration. Attached to this stub shaft is a shifter cam having a lobe which presses down on the shifter lever, disengaging the clutch whenever the control knob indicates a setting between the adjacent 20-minute and zero marks, corresponding to approximately one-fifth of a turn of the knob. For the remaining four-fifths of a turn, the shifter cam permits the shifter lever to be forced up by a spring, engaging the clutch.

Through a pair of right-angle gears the stub shaft also is connected to a lower ratchet which is concentric with the agitator shaft but not directly connected to it. The pawl which operates this ratchet is attached to the sliding rack that forms part of the main drive already discussed.



Shifter cam controlled by ratchet operated from driving rack disengages clutch on agitator shaft after the elapse of a predetermined time

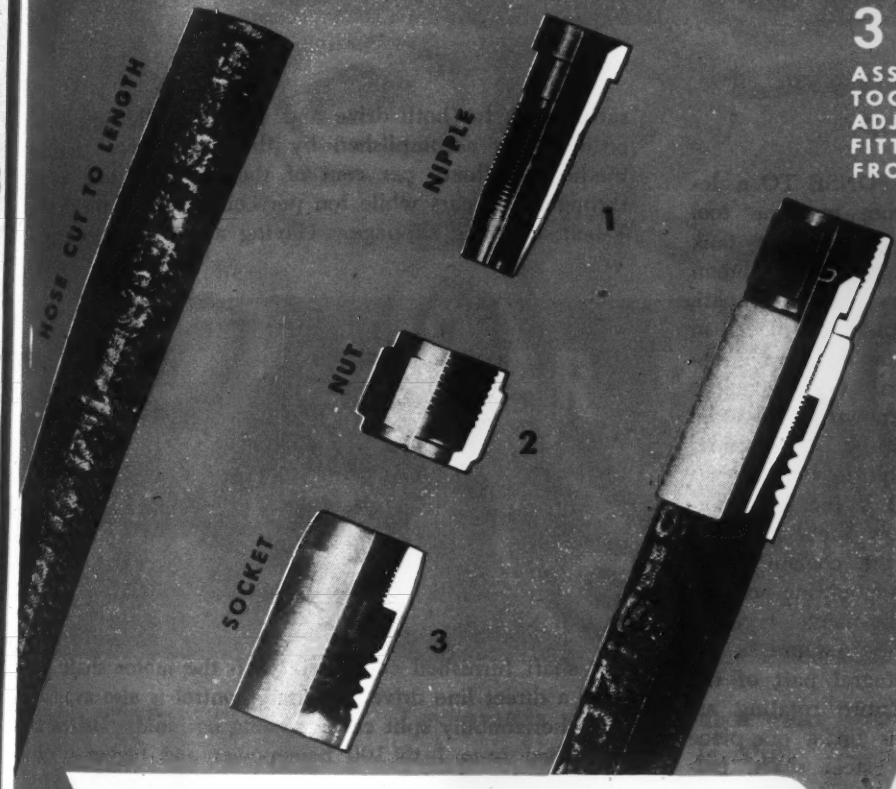
Adjacent to this lower ratchet is an upper ratchet which also is operated by the same pawl. In general, for each stroke of the rack the upper ratchet is rotated through a space of one notch. However, the teeth of the upper ratchet with one exception are shallower than those of the lower so that the lower ratchet is not actuated by the pawl except when the one deep notch of the upper ratchet is engaged by the pawl, thus permitting the pawl to engage the corresponding tooth on the lower ratchet. As a result, for one complete rotation of the upper ratchet the lower ratchet rotates only one notch. On that part of the lower ratchet corresponding to the knob setting between twenty and zero, the notches are omitted so that the pawl simply slides back and forth on a flat surface and does not rotate either ratchet. The last three notches of the lower ratchet adjacent to the smooth surface register with those on the upper rack so that when they are reached the pawl will engage these notches on every stroke and quickly, through the right-angle gear drive, shift the agitator gear out of engagement.

When the control knob is turned in a clockwise direction to the 20-minute position, the shifter cam turns to the position just beyond that in which it permits the clutch to engage. Continued rotation of the knob to any position between twenty and zero therefore advances the cam and the lower ratchet, hastening the time at which the clutch will again be disengaged. As the machine operates, the knob of course continues to rotate in a clockwise direction and at any moment indicates the time remaining before the machine is due to stop.

WAR TESTED ON AIRCRAFT ALL OVER THE WORLD
NOW AVAILABLE FOR INDUSTRIAL APPLICATIONS

3 PIECES *(EACH REPLACEABLE)*

ASSEMBLY WITHOUT SPECIAL TOOLS. NO TIGHTENING OR ADJUSTMENT AFTER ASSEMBLY. FITTINGS CAN BE REMOVED FROM HOSE AND RE-USED OVER 100 TIMES.

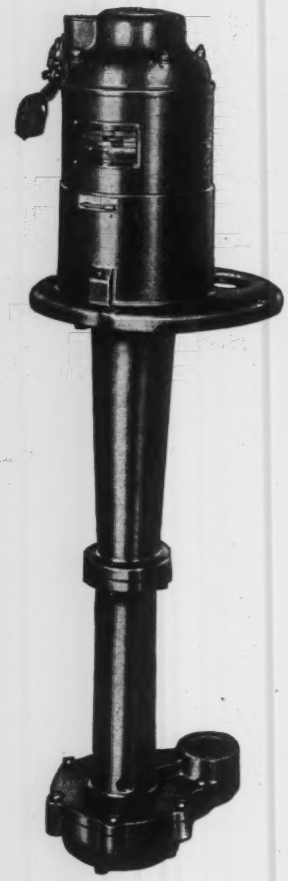


AEROQUIP CORPORATION
JACKSON, MICHIGAN, U. S. A.

★ ★ ★ 303 WAREHAM BLDG., HAGERSTOWN, MD. - 1709 W. 8th., LOS ANGELES ★ ★ ★

New PARTS AND MATERIALS

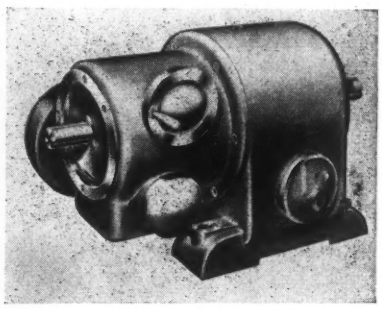
Coolant Type Pump



IN RESPONSE TO a demand from machine tool builders for greater tank capacity, The Ruthman Machinery Co., Cincinnati, has designed and placed in production its new deep-immersion type coolant pump known as Model HL-15025-B. The pump is available in two lengths —19 and 23 inches immersion below the high level line of the coolant reservoir. The mounting bracket, of circular-flange type, is 10½ inches in diameter and is an integral part of the unit. Entire rotating assembly is on a one-piece extended steel shaft, balanced after assembly, and mounted in the motor on precision ball bearings. The pump contains no packing glands or metal-to-metal contacts below the high level line. Elimination of the friction permits an adequate flow of coolant on a minimum of power consumption and attention. For continuous duty the pump is available with ¼-horsepower motor, while for extra-heavy duty it is furnished with a ½-horsepower motor, with standard current characteristics.

Variable Speed Drive

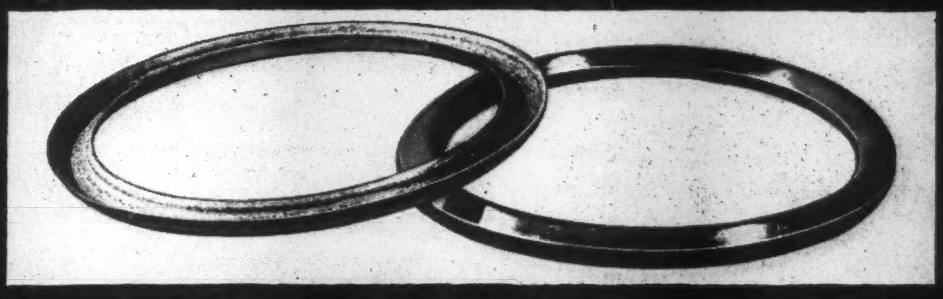
COMPACT IN construction with split-hair control, the new variable-speed drive recently improved by Lombard Governor Corp., Ashland, Mass., offers possibilities for use in the medium and higher horsepowers for geared drive power transmission. Its compactness—being scarcely larger than the motor with which it is used—recommends it for horsepowers of 15, 25, 50, 100 or higher. Long life is assured as the gears are totally enclosed and run in oil, a fact which also reduces noise and eliminates the possibility of dirt, grit and moisture getting into the gears. The drive uses a V-belt as a control medium, rather than for both drive and control. Primary speed reduction is accomplished by the conventional gearing methods. Ninety per cent of the power is said to go through the gears while ten per cent passes through the V-belt, avoiding slippage. Having a variable-speed output shaft furnished concentric with the motor shaft permits a direct line drive. Remote control is also available with horizontally split casings being optional. Drives are furnished from 1 to 100 horsepower and higher. Variable-speed ratios range between 1¼ and 1 to 70 and 0.



Constant Level Lubricator

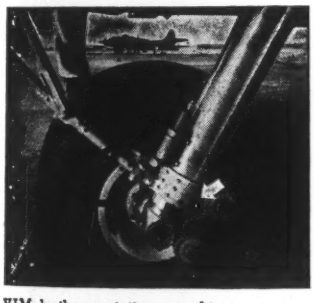
USED ON MACHINE tools, milking machines, electric motors, line shafting, counter shafting, pillow blocks, etc.—wherever bearings and machine parts must be provided with lubrication—the improved constant-level, general-purpose lubricator of Oil-Rite Corp., 3476 South Thirteenth street, Milwaukee 7, offers an automatically controlled, visible oiling method for most types of bearings. When the reservoir is filled, enough oil will be released to bring the level in bearing to the line marked on the base of the lubricator. When bearing oil level falls, air is admitted into the reservoir through a vent, automatically releasing enough oil to restore the original level. Construction consists of two simple parts. The base has bottom and side outlets for oil either or both of which may be used for bearing feed. Large air

FOR SALE-



LEATHER PACKINGS

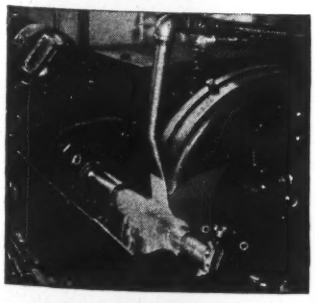
with a PAST... and a FUTURE!



VIM leather aviation packings assure proper functioning of shock struts on combat planes at all temperatures.

●

These same specially impregnated packings are now available for industrial machine applications, aiding in smooth hydraulic control.



Two years ago—even a year ago—you couldn't have bought these aviation-type leather "V" packings.

They were made for the plane winterization program, and every effort was concentrated on keeping the government supplied so that shock struts and other aircraft controls would function in all climes.

But now with air supremacy assured, and our own production facilities greatly increased, we can supply these packings to industry. Machine tool and press designers are finding them of great interest.

These new VIM leather packings are impregnated with synthetic resin, making them impervious to oils used as the hydraulic medium. They hold at low or high pressures, and at temperatures from minus 65° to 175° F.

You are invited to test them. For full data and sample set, write

E. F. HOUGHTON & CO.

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Sales and Service in All Principal Cities

HOUGHTON'S *Engineered* VIM *Leather Packings*

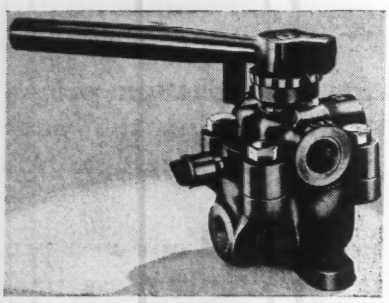
vents can be connected to a filter or to a breather tube on the bearing. Easy flow of lubricant, especially heavy oils, is permitted by large passages for oil and air. Removal of reservoir for refilling is accomplished by a conveniently located thumbscrew. The reservoir is sealed to a collar by a plastic cement, providing a strong bond which is not affected by oil, water, heat or acid. Known as Style B, this constant level lubricator is available in five sizes with capacities of 1, 2, 4, 8 and 16 ounces.

Stainless-Clad Steel Sheets

LIGHT-GAGE stainless-clad steel sheets in thicknesses from 16 to 12 gage are now being produced by Jessop Steel Co., Washington, Pa., in widths from 24 to 50 inches and in lengths up to 120 inches. The 18-gage can be furnished in all these widths and up to 96 inches in length, while polished sheets are available in all sizes up to 48 inches wide.

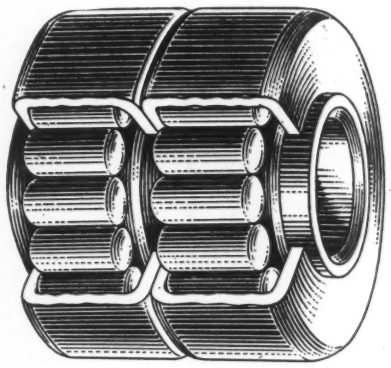
Low-Pressure Hydraulic Valve

EXPANDED USE OF ¾-inch hydraulic piping has brought about the need of a ¾-inch three and four-way operating valves for low pressure hydraulic service. The new Nopak ¾-inch hand-operated hydraulic valve has been developed by Galland-Henning Mfg. Co., Milwaukee, for leakproof service on ¾-inch hydraulic lines at pressures up to 300 pounds per square inch. Embodying features such as the cored disk, hand-lapped surfaces of disk and seat, line pressure-sealing and finger-touch control, the valve in addition incorporates a stuffing box with gland nut in the valve-stem assembly, preventing seepage of hydraulic fluid at the valve stem. This construction is also available on other sizes for use on low-pressure hydraulic lines. The new valve is made in all-bronze with lubricating channels in disk and seat for water-hydraulic service, and in semisteel without lubricating channels for oil-hydraulic service—both in hand, foot and solenoid models in a complete range of sizes.



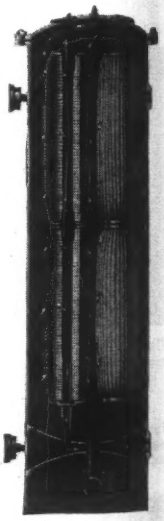
Antifriction Needle Bearings

HAVING A FRICTION coefficient as low as that of any other type of antifriction bearing, a new double row PN needle bearing has been specially designed by The Torrington Co., Torrington, Conn., to minimize friction in aircraft pulley applications. The new bearing, conforming to requirements of Specifications AN-FF-P-796, has a small outside diameter which is a weight-saving feature in the design of antifriction aircraft pulleys. Its enclosed design provides space for retention of the lubricant without excess grease being present to impede operation at low temperatures. The full complement of the small diameter needle rollers provides ample capacity to meet all standard government and individual aircraft company requirements.



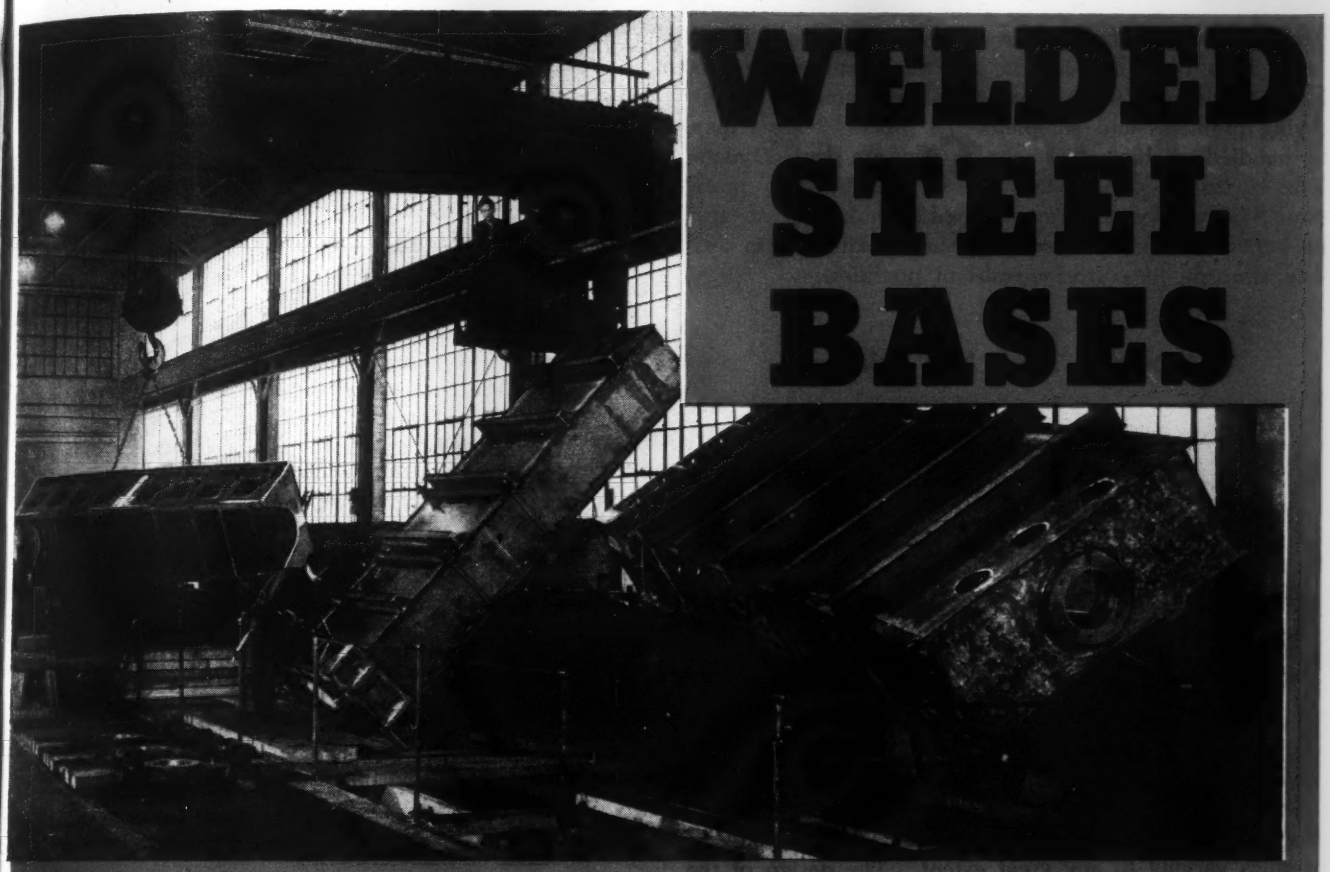
Filters for Coolants and Oils

DESIGNED FOR continuous filtration of soluble oils, low viscosity cutting oils and kerosene in metalworking machines, the ZR series filters announced by Briggs Clarifier Co., 1339 Wisconsin avenue, Northwest, Washington 7, are now available generally. The filters are built in standard models to meet most of the oil filtration requirements. Ratings are based on 3 gallons per minute flow through each refill and capacities range from 3 to 100 gallons per minute. The 100 gallons-per-minute capacity filter contains 30 refill cartridges. The cartridge is specially-treated, waterproofed, ribbed cellulose and constructed of one or two layers in either 22 or 30 folds to overall dimensions of 5 inches outside diameter by 18 inches long. It is furnished either with or without a muslin protective covering.



Coating for Zinc, Cadmium

DEVELOPED BY Rheem Research Products Inc., Baltimore, a treatment for zinc or cadmium surfaces, known as Iridite, increases the corrosion resistance and field of usefulness of zinc and cadmium coatings. Iridite is used both as a final finish and as a paint base. It is available in two natural colors, olive drab and a lusterless jet black. As a paint base, it prevents zinc from "poisoning" the paint and prevents formation of an underlayer that de-

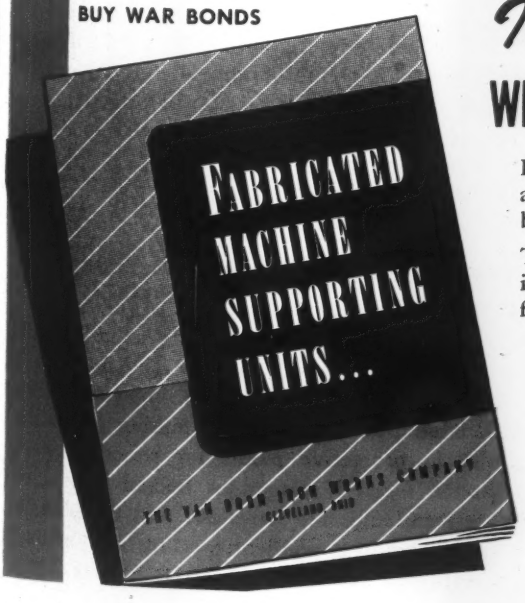


WELDED STEEL BASES

PERFORMANCE • RUGGEDNESS • ECONOMY

WELDED steel bases and frames supporting machine tools, high speed engines and special machines more than proved their superiority under the pressure of wartime production. ● New machines for peacetime production are being designed for mounting on fabricated steel structures to eliminate pattern costs . . . to permit design improvements at any time . . . to provide maximum strength with minimum weight . . . and for greater economy. ● Van Dorn offers the required specialized knowledge and experience for proper design . . . plus the facilities to economically produce welded steel supporting units.

BUY WAR BONDS



Information for you . . . about

WELDED STEEL MACHINE BASES AND FRAMES

For the convenience of manufacturers who want to investigate the many advantages of welded steel bases and frames, Van Dorn has prepared a book, "FABRICATED MACHINE SUPPORTING UNITS".

This book details the advantages of welded steel supporting units, the importance of special knowledge in designing them and Van Dorn's facilities and experience in building them.

This book will be sent to you free upon request, and will place you under no obligation.

THE VAN DORN IRON WORKS COMPANY

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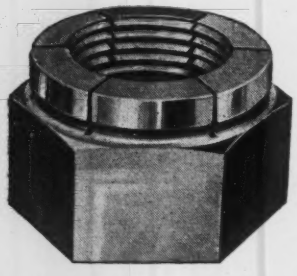
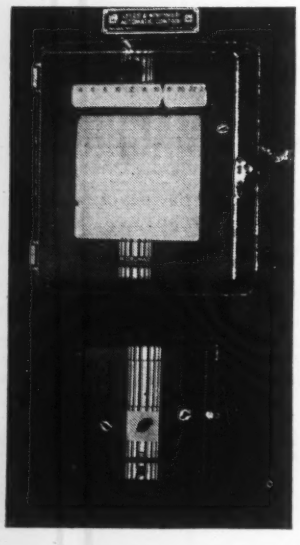
stroys adhesion. The finish is applied by dipping. Times range from 10 to 60 seconds, and temperatures from 75 to 100 degrees Fahr. Rinsing in hot water eliminates drying problems and completes the process. Parts may be handled or shipped as soon as they are dry. Dimensions or texture of final finishes are not altered by more than 3/100,000-inch. Parts treated with Iridite can also be bent or twisted without chipping, flaking, or in any way affecting its corrosion-resistant qualities.

Stop and Lock Nut Offered



OF ONE-PIECE construction of all commercial metals such as steel, brass, bronze and aluminum, the Flexloc lock nut of Standard Pressed Steel Co., Jenkintown, Pa., is also a stop nut as it is impervious to shaking loose. The top of the nut has six radial slots, as shown in the illustration, providing an equal number of sections which do the locking. These "jaws" or sections are flexible and resilient, accommodating themselves to a wide range of tolerances without the torques varying to any great extent. The design of the sections is such that the torques developed can be adjusted and predetermined within close limits—a feature where screws and other threaded members of small diameters are involved. As each of the threads, as well as the locking threads, carries its share of the load, the nut need not be any higher than a corresponding size of another nut to carry just as much load and to lock tightly. The "Flexloc" is not affected to any extent by heat or cold within the limits to which it is likely to be exposed.

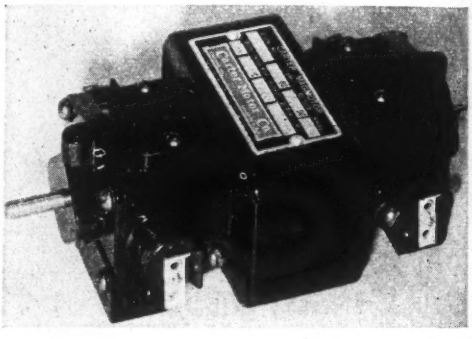
Temperature Control System



TO PROVIDE A dependable regulation of temperature in electrically-heated furnaces, ovens and similar units, Leeds & Northrup Co., 4934 Stenton avenue, Philadelphia 44, has introduced a new position-adjusting type of Micromax electric control. By means of an "on-off" contacting system, it feeds to the heating units the electric current needed to keep temperature to the required control point or program. Input is either "full-on" or "full-off". Regulation is obtained by controlling automatically the time during which current is "on" and "off". It provides full proportional time action, as compared with the more familiar full proportional positioning action. It also provides automatic droop-correction. The system can also be equipped with an overshoot control for use when the furnace or other unit is coming up to temperature.

"Straight" Generator Offered

BUILT WITH capacities to 80 watts intermittent and 35 watts continuous duty, the new "straight" generator has been added to the line of MagMotor series produced by Carter Motor Co., 1608 Milwaukee avenue, Chicago. It is furnished in a wide range of alternating and direct-current voltages, up to 500 volts at 100 cycles. Suitable for many applications where small generators are needed, the unit has the following dimensions: 5¾ x 3 11/16 x



2½ inches; weighs 4¾ pounds; and has a shaft of ¼ x 1 inch. No motor is included. Drive can be by direct couple, gear train or pulley. Utilization of permanent magnet fields eliminates necessity of a separate source to power that part of the generator, saving space and wattage. A gasoline or steam engine may be used as primary power to turn the generator where batteries are at a premium or not readily available.

Galvanized Interlocked Hose

AN ASBESTOS-PACKED interlocked galvanized steel hose with an inside diameter of 24 inches, announced by Pennsylvania Flexible Metallic Tubing Co., 7203 Powers Lane, Philadelphia 42, weighs approximately 70 pounds per foot. It is offered for use on marine and stationary diesels as flexible exhaust pipes, but also has applications outside this field. Because of its interlocked construction, it requires no special tools or heat to bend.

New Coating Resin Offered

NOW AVAILABLE without restrictions as to end use is a drying-oil resin developed by Resinous Products & Chemical Co., Philadelphia. The resin, known as Duraplex AL-210, is adapted to air-drying finishes and is designed for use in protective paints for structural steel, aluminum paints, etc. It resembles bodied linseed oil in drying speed and ultimate hardness, and the phthalic alkyds in its outstanding pigment wetting and binding properties. Supplied as a dark-colored, viscous liquid

Take a Good Look at THE SCREW

THAT'S "GEARED TO THE KEY"

Bristol Multiple-Spline Socket Set Screws set tighter . . . even in hard-to-reach places . . . without rounding out or breaking.

Where a small screw is called for . . . where vibration will be a problem . . . where the fastening point is at an awkward place — think immediately of the *screw that's built like a gear.*

The Bristo Multiple-Spline Socket Set Screw is specified for aircraft parts, photographic equipment, electrical assemblies, because the multiple-spline design (the teeth in socket are geared to the key) provides much greater strength, permitting more tightening force even on screws as small as No. 4 wire size! The diagram shows why.

Hex: Key exerts *outward* pressure against socket wall; screw will round out or break.

Bristo: Key exerts *inward* pressure; no danger of rounding out or breaking socket wall.

So Bristo Multiple-Spline Screws can be set tight to hold against vibration, yet they can be loosened with a flick of the key! See THOMAS' REGISTER for more facts, list of product applications.

Here's What You Get from the Screw that is Geared to the Key

1. Easier transmission of rotary wrenching power; hence faster assembly.
2. Tight "meshing" with the spline-shaped key; hence no key slippage.
3. No rounding out or breaking socket wall; turning key does not spread the screw.
4. Quick removal — the gear principle acting to release the screw's strong hold.

BRISTO "MULTIPLE-SPLINE" SOCKET SET **SCREWS**

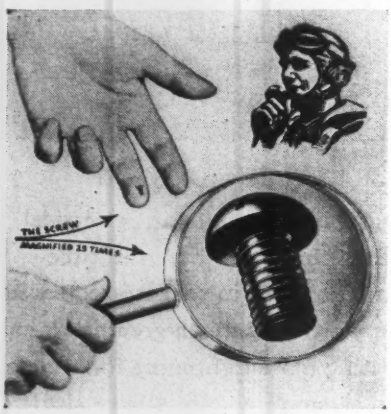
Geared to the Key — for faster, easier, tighter setting

The BRISTOL Company
MILL SUPPLY DIVISION

which pours slowly at room temperature, the resin differs from conventional phthalic anhydride resins in that its "alkyd" component is a permanently soft elastic material which does not accelerate the drying of the oil component. In combining the elasticity with the drying effect and through hardness of a hard resin, a tough elastic varnish film can be produced. Maximum air-drying speed develops five to seven days after incorporation of driers. Films of the resin are not heat-reactive and remain unchanged after short bakes as high as 400 degrees Fahr. The resin itself will body further when heated in a kettle and can be converted to a gel by heating for several hours at temperatures in the range of 450 to 475 degrees Fahr.

Miniature Machine Screws

SCREWS "SO TINY they might have been designed for your watch" have been made available by Manufacturers Screw Products, 216-222 West Hubbard street, Chicago 10. Sizes in which they are being furnished are 0-80, 1-64



and 1-72 thread diameters, both in steel and brass. The new miniature fasteners are used in various types of precision equipment and delicate instruments.

Air Filters for Diesel Engines

ANNOUNCED BY Farr Co., 2615 Southwest Drive, Los Angeles 43, the diesel air filter for diesel-engine intakes is entirely new in design. Complete and ready for attachment, it is composed of four separate filter panels of herringbone-channeled fine wire screen, 2⅛-inch thick. These are mounted with spring clips on a steel frame, permitting easy removal for cleaning or changing while the unit is in normal operation. Detailed specifications of the filter are: Capacity, 2200-3200 cubic feet per minute; air velocity, 435-635 feet per minute; static pressure (clean), .15-.29 inch; overall size, 14 14 x 22⅜ inches; weight (complete unit), 46½ pounds weight (less filters), 18½ pounds; and filter size, 8¾ x 2 x 2⅛ inches. Other capacities and sizes can be furnished also.

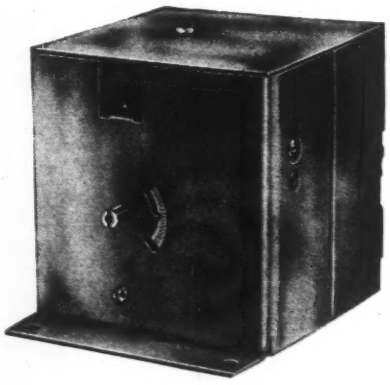
Constant Voltage Transformer

INDICATIVE OF the general trend toward built-in automatic voltage regulation of filament supplies in Army and Navy electronic equipment, the new constant voltage transformer produced by Sola Electric Co., 2525 Clybourn avenue, Chicago 14, is a small, compact unit in a

hermetically sealed case. Designed for chassis mounting, the transformer is rated at 6.3 volts, 17 volt-ampere output, and will maintain that value within ±1 per cent regardless of line voltage variations as great as ±15 per cent. It is especially valuable for the stabilization of oscillator circuits.

Impulse-Initiated Timer

RECENTLY INTRODUCED by Struthers-Dunn Inc., 1321 Arch street, Philadelphia 7, a new compact, shockproof, impulse-initiated timer is 72 per cent smaller by



volume than previous units used for similar applications. Known as Type PSEH-1, the timer is available in both alternating and direct-current types: For the former on 110 volts 60 cycles or 25 cycles, 220 volts 60 cycles or

Finer Drafting Room Equipment
PRECISION INSTRUMENTS

ESCO Products
REG. U.S. PAT. OFF.

"Symbol of Superiority"

for Architects Navigators Engineers Draftsmen Artists and the **SCHOOLS OF THE NATION**

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TRIANGLES
PARALLEL RULERS
STRAIGHT EDGES
DRAWING KITS
TABLES
DRAWING BOARDS

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Our New Automatic Tilt-Top Table, also our NEWEST DRAFTEDGE MACHINE (Patent Pending)

DEALERS will profit by window dislpays of ESCO Products—Write for our NEW 4-colored die cut DISPLAY CARD Size 14 x 22

New!! ADJUSTABLE AND REVOLVING DRAWING BOARDS

"A Craftsman is no better than his tools"

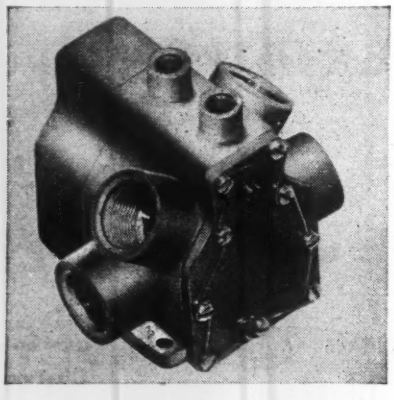
WE HAVE THE TOOLS FOR DELIVERY NOW!

SHEBOYGAN **ENGINEERING MANUFACTURING CO.** WISCONSIN

25 cycles; or for direct-current operation at any specified voltage from 60 to 120 volts. Contact operation occurs at the end of a delay interval after power has been applied, or after receipt of a momentary impulse from a push-button, limit switch, or other source. The adjustable timing range is 20 to 1, and the mechanism is immediately recycling. A built-in double-pole, double-throw auxiliary provides a variety of circuit arrangements common to, or isolated from, the control circuit. Size of the unit relay provides a variety of circuit arrangements common is 3½ x 3⅝ x 3¾ inches.

Four-Way Control Valve

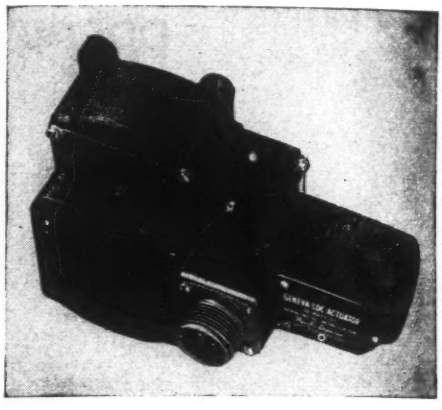
ANNOUNCED BY Adel Precision Products Corp., Burbank, Calif., a new remote positioning 4-way control valve permits regulation of high-pressure hydraulic systems with the company's ISOdraulic remote control system. It is adaptable, in combination with other standard units, to a large variety of control installations such as positioning of wing flaps, dive brakes and steerable nose wheels in



aircraft, as well as to hydraulic operation of roadworking, automotive and marine equipment. Weight savings have been accomplished through use of the ISOdraulic controls comprising an independent system operating from −65 degrees to 165 degrees Fahr., with either master or slave, or both, at either extreme. The unit illustrated has a 16 gallon-per-minute flow, 3000 pounds per square inch pressure, and is designed for ¾-inch lines. Units for other flows and pressures are also available.

Positioning Actuators Offered

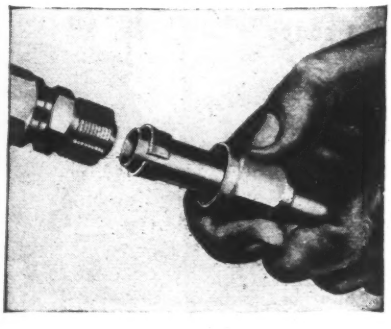
INCLUDED IN THE new line of electric actuators being produced by the Pacific division, Bendix Aviation Corp., North Hollywood, Calif., are a Geneva-loc positioning actuator and a specialized actuator. The latter is for operation of dive flaps to meet specifications of an airframe manufacturer. The Geneva-loc actuator provides accurate control within 1 degree of any series of operations up to eight positions, with each being locked against movement. As implied in the name, a geneva movement is incorporated which operates by a high-speed motor. Positioning by limit switches has been eliminated. Some of the advantages are: Positive control of output shaft movement which automatically locks at all stops and is independent of motor overtravel and temperature variations. Motor comes up to speed under no load, then engages cam with varying ratio which develops maximum



torque at breakaway positions. Thus cutout switches operate when motor is under no load, permitting maximum switch life. The design permits two to eight positions. Applications of the actuators include the remote operation of hydraulic valves, two-speed supercharger controls, fuel selector valves, spark retard, prop feathering, air duct valves or any other similar installation where accurate positioning is required.

Self-Flaring Coupling

FOR FLEXIBLE plastic tubing, a self-flaring coupling has been announced by Packless Metal Products Corp., 31 Winthrop avenue, New Rochelle, N. Y. The flare is formed as the members of the coupling are screwed together in one operation, assuring uniform walled flare with no thinning toward the end to weaken the tube.

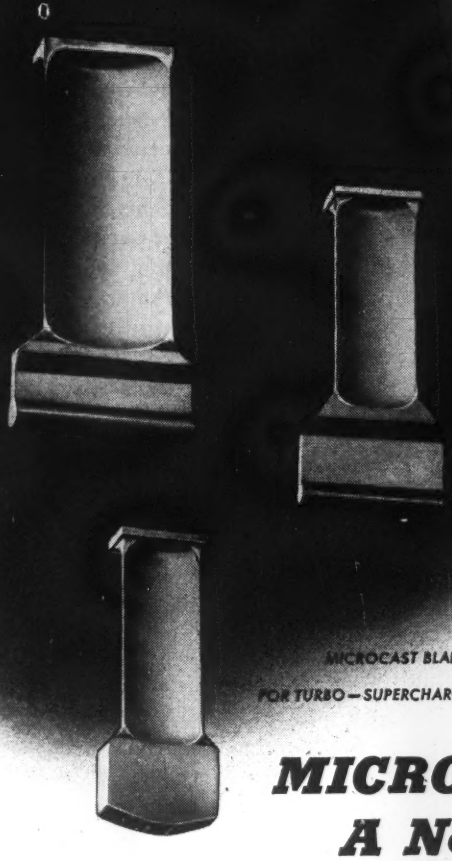


The plastic tubing is not preheated. According to the manufacturer, this construction eliminates twisting and distortion of the tubing as well as split ends. Coupling may be reused and is available for tube sizes of ⅛ to ¾-inch outside diameter.

Starters for Mine Equipment

ALTERNATING-CURRENT, full-voltage, explosion-proof starters for application on equipment used in gaseous mines have been announced by the Industrial Con-

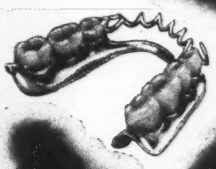
MICROCAST PRECISION CASTINGS PROCESS



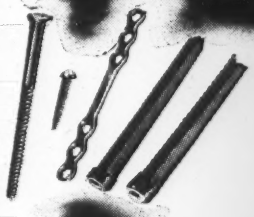
MICROCAST BLADES FOR TURBO—SUPERCHARGER WHEELS

EVOLUTION OF THE MICROCAST PROCESS

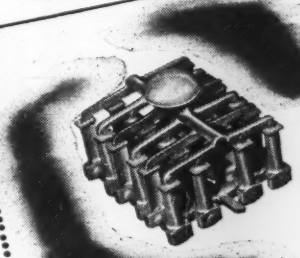
Dentistry....
The MICROCAST PROCESS was developed in conjunction with the introduction of the alloy, Vitallium,* to the Dental Profession. The casting of this alloy required the development of an entirely new and revolutionary precision casting technique.



Surgery....
Surgical plates, nails, screws and special appliances have been made by the MICROCAST PROCESS since 1937. These Vitallium* surgical appliances are widely used in the field of orthopedic surgery for the internal fixation of fractures and in other surgical applications.



Industry....
For three years, the MICROCAST PROCESS has been utilized in the quantity production of castings which have fine dimensional precision as cast and require little or no machining. Smooth surfaces and dimensional accuracy of the cast parts approach those of machined parts.



*Vitallium, a non-machinable alloy

MICROCAST— A New Precision Casting Process

MICROCAST is a term applied to the mass production of smooth, sound castings of unprecedented dimensional precision made by the AUSTENAL MICROCAST PROCESS.

The MICROCAST PROCESS is an application commercially of the investment technique of casting, originally developed and perfected by Austenal for the precision casting of intricate dental and surgical appliances. In quantity production, scores of millions of blades have been cast to precise tolerances for the turbo-supercharger wheels on U. S. Bombers and Fighters.

Many other castings of diversified shape, detail and design have been made of various metals and alloys by the process. The smooth surfaces and dimensional accuracy of these castings approach those of machined parts.

While this new process does not displace or limit conventional forging or machine shop methods, it represents an advancement in casting procedure, due to the precision and smoothness of the castings, regardless of their complicated shape. Hollow (cored) castings, and parts with internal and external threads are being successfully MICROCAST.

Industrially, MICROCASTING of parts to close tolerances offers in many instances definite economies in the casting of some of the high-melting point alloys which are very difficult to forge and machine on a commercial basis.

Consider the MICROCAST PROCESS in your present and postwar planning.

AUSTENAL LABORATORIES, INC.
224 East 39th Street, New York 16, New York
5932 S. Wentworth Avenue, Chicago 21, Illinois

MICRO CAST

The precision process originated by Austenal Laboratories, Inc. sixteen years ago for the production of castings of intricate design where accurate dimensions and surface smoothness are absolutely essential. Many castings produced by the MICROCAST PROCESS require little or no machining.

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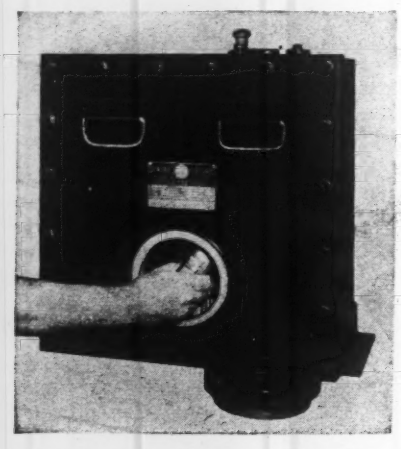
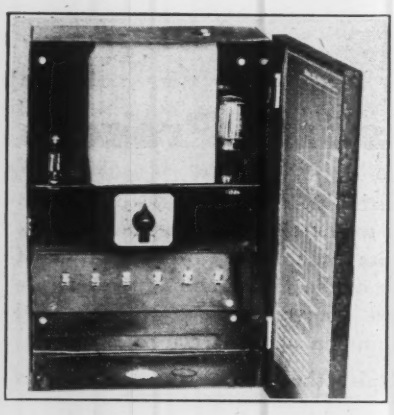
trol division of General Electric Co. Housed in heavy, explosionproof enclosures fabricated of steel plate, these starters are available up to 50 horsepower in the reversing type and up to 100 horsepower in the nonreversing type. A wide flange between the cover and the body of the enclosure is ground to close tolerances to prevent the escape of burning gases. The switches, contactors and



overload relays in these starters are also of heavy-duty type, and are designed and located to permit a considerable variety of magnetic interlocked control arrangements. Access to the line fuses is through a hand-hole cover. The starters are furnished with bellmouthed packing glands to match the size of the cable to be used, and a cable retaining clamp is also furnished with each starter if required.

Electronic Timer Capacitor



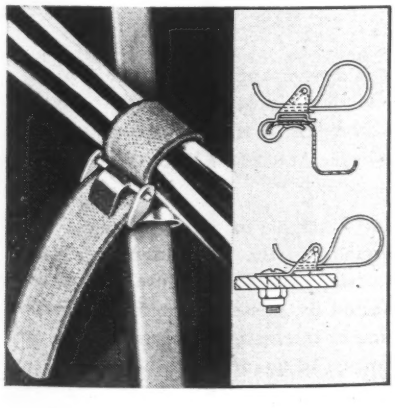
DESIGN OF THE Series A and B industrial electronic timers and contactors has been improved by the manufacturer, Electronic Products Co., 19 N.E. First street, Geneva, Ill. The Series B, shown in the accompanying illustration, is for heavy-duty work, and has a time control from ½ to 45 cycles. It is also an electronic contactor for loads up to 15 kilovolt-ampere demand loads. Heat control in stepless variation from 1 to 100 per cent permits accurate control of welding temperatures, with no loss of power. Xenon filled power tubes are used to assure quick starting and operation under all temperature conditions. The Series A timer is suited to all short-time operations of 45 cycles or less in increments of ½-cycle. This timer also may be used as a contactor for any load up to ½-kilovolt-ampere. As a timer it can be used to control heavy-duty contactors of mechanical or electronic tube type. Contacts are rated at 10 amperes at 110 volts, 5 amperes at 220 volts or 2.5 amperes at 440 volts. Dimensions of the Series A are 12 x 8 x 4 inches; weight, 10 pounds; while the Series B timer is 20½ x 12½ x 7 inches and weighs 30 pounds.

Insulating Resins Announced

NOW IN COMMERCIAL production, according to Dow Corning Corp., Midland, Mich., is a new class of organo-silicon insulating materials which are high heat and moisture resistant, and free from carbonization at high temperatures. Several types of these insulating resins are available—each for a specific requirement. One type, known as No. 993, is employed as an impregnant and coating for Fiberglas covered magnet wire and for woven Fiberglas electrical tapes, cloth and sleeving. It requires high temperatures to cure to a tack-free state; 1 to 3 hours at 250 degrees Cent. or shorter times at 350-400 degrees Cent. The combination of this material with Fiberglas provides flexible continuous insulating constructions which will withstand long operating temperatures of 150-200 degrees Cent. in electrical equipment. Another type, No. 2052, is intended as an impregnant and thermosetting dielectric for rotating parts of electrical equipment. It was designed primarily to be resistant to centrifugal displacement in parts of electrical equipment rotating at high speeds and at elevated temperatures.

Wire Harness Support Strap

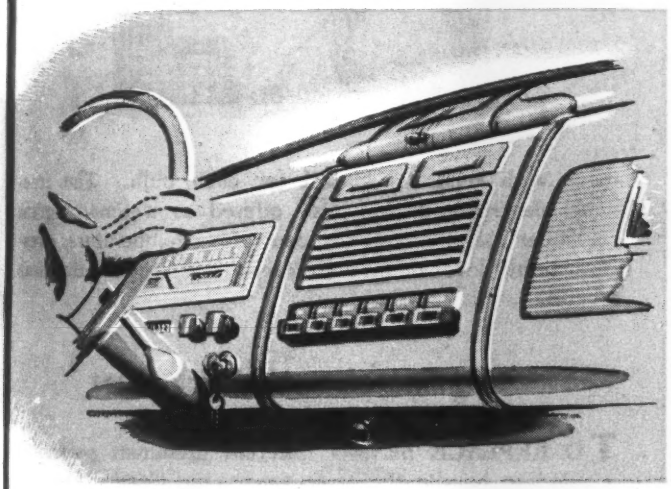
ANNOUNCED BY the Line Support division of Adel Precision Products Corp., Burbank, Calif., is a new simplified universal electric wire harness support strap, designed to permit quick one-hand installation and removal of wires. The new support consists of a lightweight, synthetic, sponge-rubber coated fabric strap ⅝-inch wide which has a 2800 pounds per square inch tensile strength.

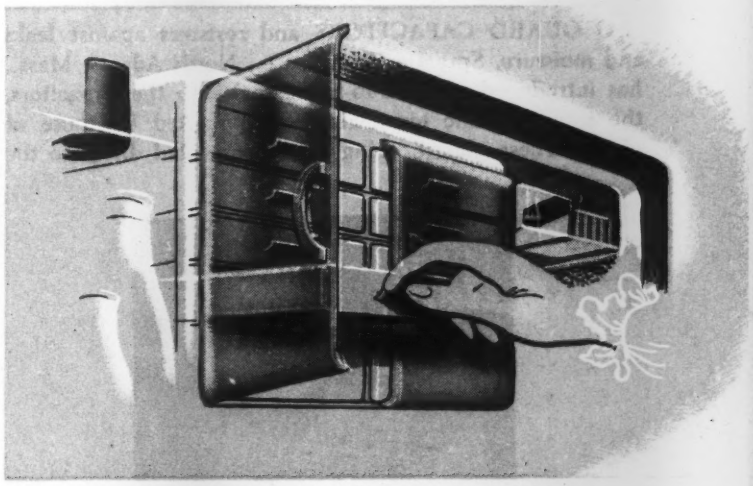


A simple buckle is mounted on a 360-degree swivel-latch, permitting attachment at any angle. One size of strap replaces all sizes of harness clips as it will support one to fifteen wires cushioned by the sponge rubber. When a single wire is carried, strap end may be clipped off. Several types of mounting brackets are available which clamp securely to airframe structure without necessity of drilling holes, as shown in illustration. The strap can be

Why Are They Calling Styron THE Postwar Thermoplastic?

Reason enough—Styron (Dow Polystyrene) is changing plastic plans because its price, properties, and production influence nearly every choice.





There is already ample proof that plastic plans will start with Styron (Dow Polystyrene) in the postwar period. This great thermoplastic material has so many valuable properties and is capable of doing so many things that it has been in big demand for war duties. Naturally, production facilities have been expanded tremendously. As a result, Styron will probably be among the first plastics to be available for big jobs after the war. And this huge production means that the price will be exceedingly attractive—as it is today.

These factors, plus its well-known properties, all point to big uses for Styron. It will be in demand for precision moldings that must retain their shapes and details . . . for jewelry, trim and decoration for installations requiring immunity to acids and alkalies . . . for countless other decorative and industrial applications.

Keep your eye on Styron—it is the outstanding postwar plastic. Write for further details.

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

New York • Boston • Philadelphia • Washington • Cleveland • Detroit • Chicago
St. Louis • Houston • San Francisco • Los Angeles • Seattle

DOW PLASTICS INCLUDE

STYRON . . for fabricators producing moldings, extrusions, rod, sheet.

ETHOCEL . . for fabricators producing moldings, extrusions, coatings; available also as Ethocel Sheeting.

SARAN . . . for fabricators producing moldings, extrusions, pipe, tubing, sheet; available also as Saran Film.

STYRON

(DOW POLYSTYRENE)

From the only privately owned synthetic styrene plant with sufficient facilities to care for molders' postwar requirements.

DOW

CHEMICALS PLASTICS MAGNESIUM

INDISPENSABLE TO INDUSTRY AND VICTORY

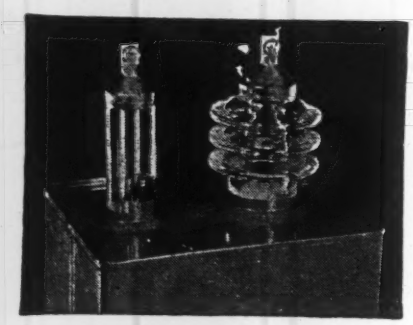
furnished with screw or rivet hole provision, depending upon requirements (also illustrated). According to cold-box tests, the strap retains flexibility at −70 degrees Fahr.

Circuit Breaker Announced

ANNOUNCED BY The Heinemann Circuit Breaker Co., 113 Plum street, Trenton, N. J., is an improved single-pole circuit breaker for 240-volt alternating current and 125-volt direct current, 50-ampere maximum. The breaker may be front-connected or rear-connected, and has an instantaneous trip or a selection of three time delays. Overall dimensions are 5¼ x 2 11/16 x 1½ inches.

Glass-to-Metal Seals

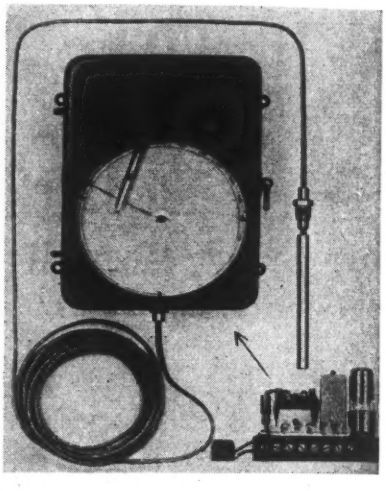
TO GUARD CAPACITORS and resistors against leaks and moisture, Sprague Electric Co., North Adams, Mass., has introduced its glass-to-metal seal. In the capacitors, the usual ceramic terminals are supplanted by those of glass. These glass bushings are then sealed direct to the



metal capacitor container. On the resistors, the resistance unit is encased in a special glass tube which is sealed directly to the metal ends. The resulting seals make glass and metal a solid, integral unit, and are leakproof, shockproof and humidityproof. Sizes range from very small up to 3 inches in diameter. The seals work equally well on any metal including steel, brass and monel, and are now available in 8000 different electrical characteristic combinations.

Free-Vane Electronic Controller

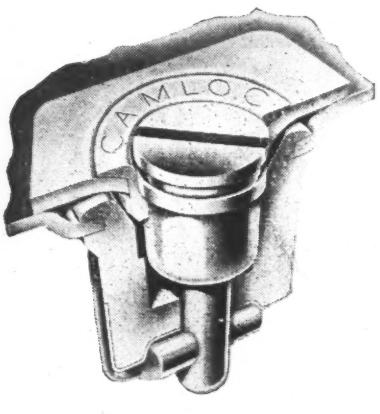
ANNOUNCED BY The Bristol Co., Waterbury 91, Conn., the new free-vane electronic controller operates on the shielding effect of a vane passing between two coils in an electronic circuit. Recording and indicating models are available for low-open, high-open, low-high, low-open-high, and low-normal-high control operations, for temperatures, pressures, liquid levels, and humidity. The controller for temperature is offered in ranges from −125 to 1000 degrees Fahr. for use in conjunction with motor and solenoid valves, relays, main line switches, and other fuel control apparatus for controlling temperature in electric, oil, gas-fired and steam-heated ovens, dryers, dehydrators, oil baths, smoke houses, tanks, and other similar industrial equipment. The pressure controller is being furnished in ranges from full vacuum to 6000 pounds per square inch, and in addition is available for automatically controlling liquid level. The controller for humidity operates from a wet and dry bulb type of ele-



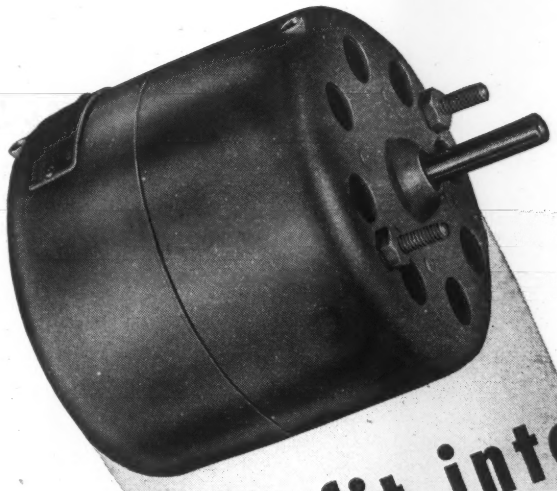
ment with separate control for each bulb. The free-vane electronic unit is also offered as a time-program controller for automatically controlling temperature, pressure, liquid level or humidity according to a definite time schedule.

Grommet for All Thicknesses

TO REPLACE SEVEN different grommets previously needed to handle the same range, the Camloc Fastener Corp., 420 Lexington avenue, New York 17, has introduced its new grommet for its 4002 series quick-acting fastener. The new grommet, flush-mounted, may be used on all sheet thicknesses. It is made of steel and permanently secured in the panel. A preformed flange on



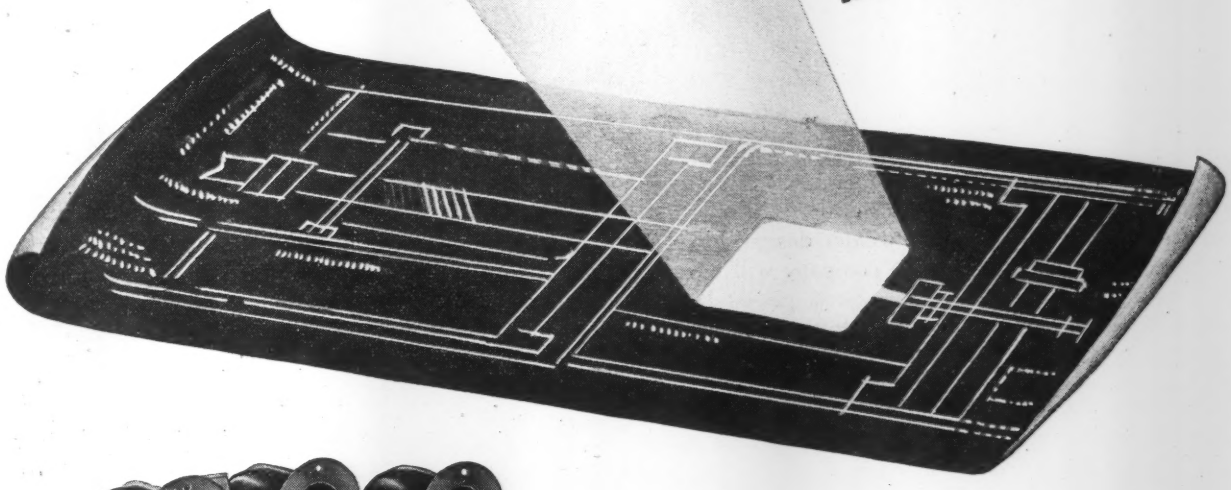
the outside gives uniform strength characteristics irrespective of the application. Requiring only a shallow dimple, the grommet keeps sheets from cracking at the edge of the dimpled hole. It does not rotate with the stud assembly, so that the sheet is protected from spalling. The tapered design and the fact that the removable stud assembly retracts in the grommet permit installation of the fastener on sharply curved sheets.

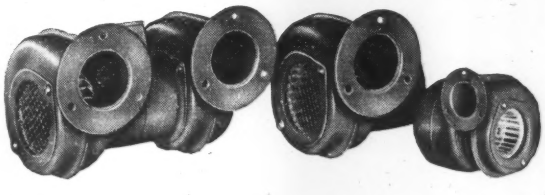


does this fit into your plans?

Does your post-war product now being designed require a compact, dependable power drive? If so, you may find the motor you want in the standard line of Pilot Shaded Pole Motors. Our ability to deliver (under current regulations, of course) will surprise you.

Tell us **your requirements. We will send specification sheets giving details of the motors. Pilot Motors are available in types for continuous or intermittent duty, with ratings from 1/15 to 1/500 H.P. Open or enclosed cases, in plain round, or with base or resilient mounting.**





Pilot Blowers . . . economical, dependable are available in three standard models, delivering 15, 50, and 100 C.F.M. Ask for Bulletin 507.

F. A. SMITH MANUFACTURING CO., INC.
401 DAVIS ST. ROCHESTER 2, N. Y.

Pilot Shaded-Pole MOTORS

FASCO

K. Swanson

W. Kaiser

Joseph L. Trecker

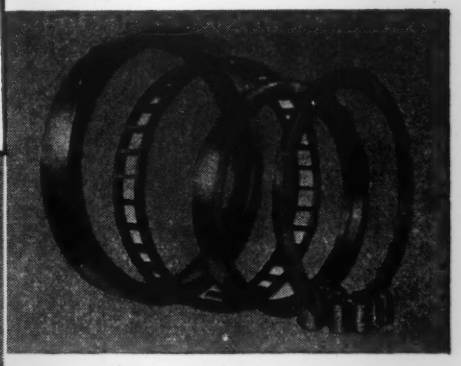
MEN...of...machines

K SWANSON, formerly chief engineer of Federal Machine & Welder Co., has joined Progressive Welder Co., in the same capacity. Considered an authority on resistance welder design, Mr. Swanson in his new capacity as chief engineer of the company will have complete charge of the design of its line of portable guns, pedestal, spot, seam, butt and projection welding machines, in addition to the new line of battery welders. A graduate of Wentworth Institute in mechanical engineering, Mr. Swanson's experience in the welding machine industry includes that of chief engineer of Eisler Engineering Co., general superintendent of Birdseye Electric Corp., plant superintendent of Bendix Aviation Corp. in its marine division, and chief engineer of Federal Machine & Welder Co. This background will be of assistance to him in his duties as chief engineer of the Federal organization.

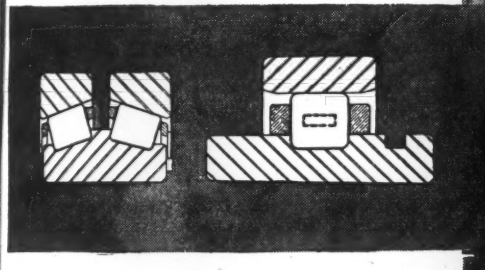
W KAISER, who has a wide experience in welding-machine design, will assist K. Swanson on further development and application engineering on the new battery welder line of Progressive Welder Co. Formerly design engineer with National Electric Welding Machines Co., Mr. Kaiser is a graduate of Michigan College of Mining and Technology in mechanical engineering, and has had extensive electrical engineering training and experience. Prior to his new appointment at Progressive he had filled the following positions: Tool engineer for several Detroit plants, most recently the Hercules Engineering Co., and previously design engineeer for National Electric Welding Machines Co. and Federal Machine & Welding Co.

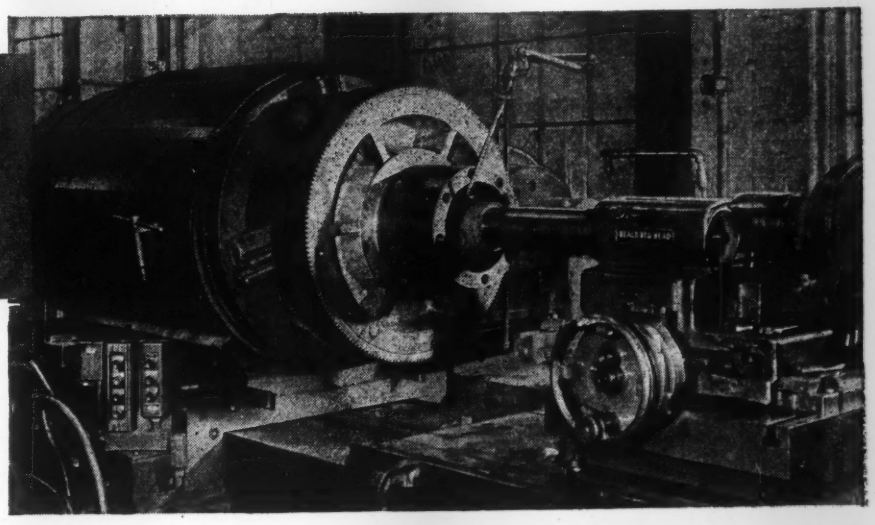
JOSEPH L. TRECKER has recently been elected president of the National Machine Tool Builders' association. Since 1942 he had been a director of the association, and is also a member of the Machine Tool Industry's Advisory Committee to the War Production Board —a background which will be of considerable assistance to him in fulfilling the various duties of his new post as president of the association. He is also vice president and director of Kearney & Trecker Products Corp. and a director of The Controls Corp. Mr. Trecker in December 1940 had been appointed expert consultant to the Secretary of War,

IN THE NEWS
WITH TORRINGTON BEARINGS

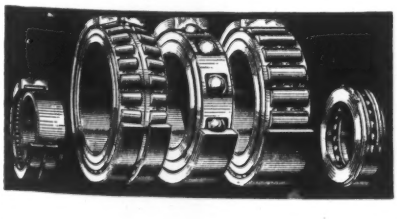


MEETING DESIGN REQUIREMENTS of the Emsco Derrick & Equipment Company, the engineers of Torrington's Bantam Bearings Division custom-built the 27½" O.D. Radial Roller Bearings employed in the sheaves of the crown and traveling blocks. The bearings, mounted on a center drum, are located close to the rope grooves to conserve wire line, prevent hazardous tilting, and to minimize wear on the sheaves.



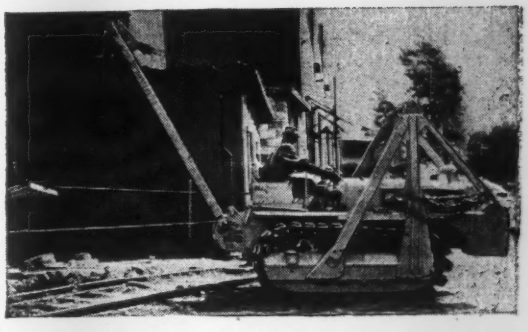


GRINDING HEAVY PARTS TO PRECISION LIMITS, this mammoth grinder, built by the Ingersoll Milling Machine Company, utilizes a Torrington Tapered Roller Bearing to carry the heavy radial and thrust loads encountered in the operation of the spindle. It is mounted directly behind the chucking mechanism which holds the work in position for grinding. A tapered bore radial roller bearing is mounted on the back end of the spindle, where a "V" belt pulley connects direct to the motor drive. After four years in operation the eccentricity and face run-out of these bearings is .00025.



EVERY MAJOR TYPE OF ANTI-FRICTION BEARINGS is included in the Torrington line—straight roller, tapered roller, needle and ball. In addition to supplying every branch of industry with a wide range of standard bearings, the engineering staff of Torrington's Bantam Bearings Division designs bearings in large sizes and of special types for new or unusual applications. For experienced counsel in meeting today's requirements—or assistance in postwar plans TURN TO TORRINGTON.

DESIGNERS of this Williamette Hyster towing winch, installed on a Caterpillar tractor, specified heavy-duty Torrington Needle Bearings for use in the idler and reverse gears. The Williamette Hyster Company says, "Because of the restricted space in the comparatively small gears, needle bearings are the only practical type of anti-friction bearings that can be used."



ARMY E NAVY

TORRINGTON BEARINGS

STRAIGHT ROLLER • TAPERED ROLLER • NEEDLE • BALL

THE TORRINGTON COMPANY • BANTAM BEARINGS DIVISION

SOUTH BEND 21, INDIANA

and in 1941 organized and became Chief of Subcontract Branch of the Office of Production Management. He served as Deputy Director of the Contract Distribution Division of that office.

WILLIAM M. KAUFFMAN, who recently was appointed assistant to the chief engineer in charge of diesel engine development for Mack Trucks Inc., will supervise the company's enlarged facilities for diesel research and development. Mr. Kauffman—a graduate of Illinois Institute of Technology—has had twenty years' experience on diesels. This includes his work as assistant chief engineer of the engine research and development division of Worthington Pump & Machinery Co., Buffalo, and as chief development engineer of the National Transit Pump & Machine Corp., Oil City, Pa. He also has held posts as chief design engineer of Baldwin De La Vergne, Philadelphia, and research engineer of the Superior Engine division of the National Supply Co., Springfield, O.

♦

DR. L. F. FULLER, formerly assistant chief engineer of Joshua Hendy Iron Works, has recently been appointed chief engineer of the company.

♦

R. E. BRESSLER, who has been vice president and chief engineer of Kol-Master Corp., Oregon, Ill., has been elected president and treasurer.

♦

DAVID J. BONAWIT has been made chief engineer of the Marshall-Eclipse division, Bendix Aviation Corp., South Bend, Ind. He previously had been executive engineer of the Manhattan division of Raybestos-Manhattan, Inc.

♦

JULIUS A. CLAUSS, chief engineer, Great Lakes Steel Corp., has been appointed vice president in charge of engineering. Mr. Clauss served as special assistant to the director of the WPB Steel division during 1943.

♦

R. G. WINGERTER, an industrial engineer with The Timken Roller Bearing Co. for the past six years, has been appointed assistant chief engineer for the industrial division of the firm.

♦

GEORGE L. SNYDER, who since 1938 has been chief engineer of Lukenweld Inc., has been made chief engineer and assistant to the general manager.

♦

C. W. CAMP, formerly connected with Crocker-Wheeler Electric Mfg. Co. for 38 years, specializing in application engineering, is now associated with Worthington Pump & Machinery Corp., Harrison, N. J., as consulting electrical engineer.

♦

ROBERT CROOKS STANLEY received the American Society for Metals medal for the advancement of research during the annual dinner of the society. Mr. Stanley is chairman and president of The International Nickel Co. of Canada Ltd.

♦

CORNELIUS E. BURKEY, a designer and development engineer, has been appointed chief engineer of Designers for Industry Inc., Cleveland.

♦

DONALD C. HULSE has been appointed design engineer of George L. Nankervis Co. Mr. Hulse has been connected with the DeSoto division of the Chrysler Corp. where he supervised the design and installation of metal finishing equipment. Prior to this connection, he was in the engineering department of Great Lakes Steel Corp.

♦

DR. EDWARD U. CONDON, well known scientist in the field of theoretical physics, has been elected to membership in the National Academy of Sciences. Dr. Condon is associate director of the Research Laboratories, Westinghouse Electric & Mfg. Co.

♦

C. W. LA PIERRE has been named assistant engineer, General Electric general engineering laboratory. Since 1936 he has been in charge of the electro-mechanical sections of the laboratory, directing development and production of special measuring instruments and electro-mechanical control devices. For the development of the photoelectric recorder he received a Coffin Award in 1937.

♦

J. W. WILKINSON has become connected with Hastings Mfg. Co., Hastings, Mich., in its engineering department.

♦

ARTHUR H. FRIES has been promoted from experimental engineer in the Commercial Car Division, Chrysler Corp., Highland Park, Mich., to chief engineer of the plant.

♦

C. H. SPECK, who had previously been in the staff engineering department at Hoover Co., has joined Higgins Aircraft Inc., New Orleans, La., as assistant chief research engineer.

♦

MICHAEL BIFANO is now hydraulics group leader of Fisher Body Aircraft Development Section, General Motors Corp., Detroit. He previously had been president and chief engineer of Bifano Aircraft Co., Detroit.

♦

RICHARD H. OWENS, formerly chief model test engineer for Dodge Chicago Plant, Chrysler Corp., Chicago, is now employed as a project engineer on development work for Jack & Heintz Inc., Bedford, O.

♦

EDWIN M. FISK has become engineer in charge of diesel development for Reed Mfg. Co., Los Angeles. He formerly had been chief engineer for Fisk Airplane & Engine Co., Mission San Jose, Calif.

Molybdenum cast steels make tough, wear-resistant parts. Our data on practical analyses are always available.

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

ARMY E NAVY

MOLYBDIC OXIDE, BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"

Climax Molybdenum Company

500 Fifth Avenue · New York City

MOLY

Vibration and Noise

(*Continued from Page* 146)

fatigue failure of four of its five crankshafts. The trouble was due to the occurrence of a critical speed at 1380 revolutions per minute, right in the middle of the operating range which was 1320 to 1450 revolutions per minute. Installation of the couplings "detuned" the system to a natural frequency below the operating range.

Another interesting application of this type of coupling is the one shown in *Fig.* 46, representing an engine-driven pump unit for an L. S. T. Preliminary calculations showed that with a rigid coupling the torsional vibration in the working range of 1450 to 1800 revolutions per minute would be sufficient to fracture the pump shaft. Employment of the double piloted coupling shown in *Fig.* 46 resulted in a maximum stress in the pump shaft of only 2600 pounds per square inch, measured by strain gage. In this case the principal disturbance was the third order, because the six-cylinder four-stroke cycle engine has three firing impulses per revolution. With the couplings, the natural frequency in the first mode was 1837 vibrations per minute, making the 3rd-order first mode critical speed only $1837/3 = 612$ revolutions per minute.

A type of coupling which also possesses the necessary combination of resilience and damping is the Airflex. Designed particularly for the mitigation of torsional vibration in fluctuating drives, the coupling consists primarily of a rubber gland through which the power is transmitted, and which includes an inner and outer member. Inner member is similar to the inner tube of an automobile tire and is kept inflated with air. The outer member is built up of multiple layers of fabric and rubber and is bonded

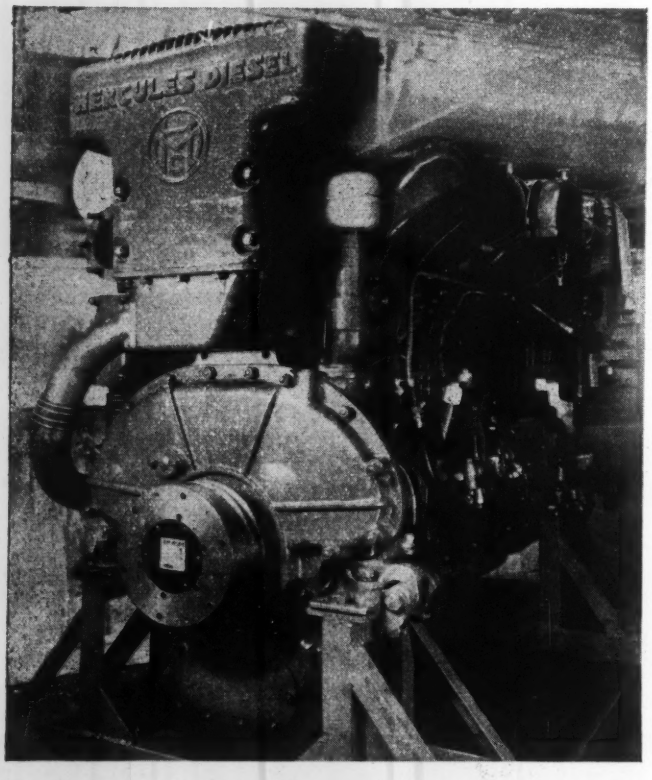


Fig. 55—Torsional vibration damper is shown installed on the end of the crankshaft of a diesel engine

to the inner member as well as to inner and outer ri connected to the driving and driven shafts. The stiffn factor k can be controlled by varying the air pressu within the gland, while the damping due to hysteres in the rubber is nearly constant for all vibratory stress below the fatigue limit of the rubber.

Vibration dampers or absorbers are another valuabl aid in the suppression of torsional vibration. Their ob ject is to furnish a torque which at all times opposes th tendency toward vibration. To be effective a dampe should be located away from a node, and usually i placed at the driving end. Essential elements of such device include a small auxiliary flywheel driven from th shaft through a spring, or by friction or even through th medium of a viscous liquid. In the case of the friction drive (Lanchester-type damper) a spring-loaded clutch connecting the auxiliary flywheel to the main system i set to slip when the accelerating torque exceeds a predet termined amount, which depends on the amplitude and frequency of the vibration at the point of attachment o the damper. Work done in slipping against friction ab sorbs energy and reduces the vibration amplitude. Th action with viscous liquid is somewhat similar but th opposing torque varies as the velocity of slip instead o being approximately constant as in the friction drive.

A damper employing a spring is illustrated in *Fig.* 5 It consists of a primary hub attached to the shaft and a

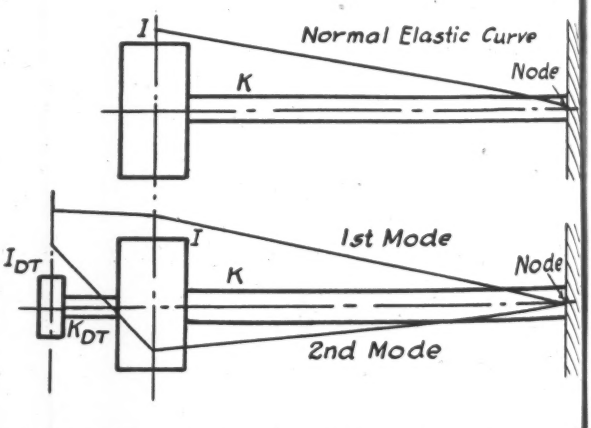


Fig. 56—Simplified single-degree of freedom system is converted by damper into one having two degrees

secondary hub to which is attached the auxiliary flywheel, which is known as the "detuning" flywheel. The spring connector is of the type used in the Steelflex coupling al ready discussed, and possesses the same properties of inherent and apparent damping. An idea of the size of such a damper relative to the machine on which it is installed may be gained from *Fig.* 55. The basic principle in applying this type of damper is to proportion the mass of the detuning flywheel and the stiffness of the spring so that the average natural frequency of the damper unit is equal to or slightly less than that of the main system without it. The detuner then vibrates and exerts a torque in opposition to the oscillation of the main shaft at the point of attachment. To be effective the detuner flywheel must of course be sufficiently massive to handle the external disturbing torque.

Action of the damper may be further explained with reference to a simplified single-degree of freedom system,

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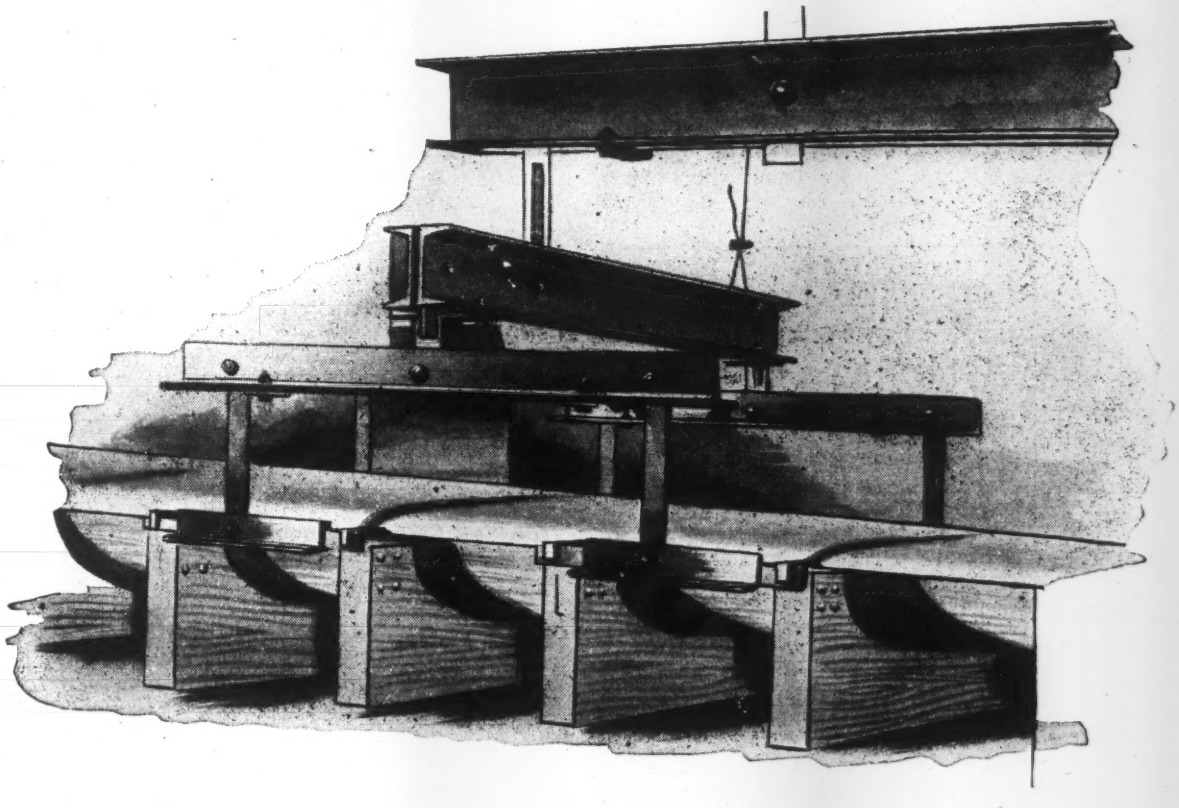

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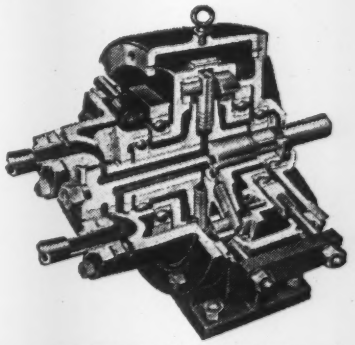

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Fig. 56, in which the right-hand disk is so massive that the node is always located there. Addition of the detuner to this two-mass system converts it into a three-mass system having two modes of vibration, *Fig.* 56. In the new system the amount by which these two frequencies differ from the original depends on the size of the detuner flywheel I_{dt} compared with the main mass I, a large value of the ratio I_{dt}/I giving a wide spread. Proper "tuning" of the damper also depends on this ratio. Thus if the natural frequency of the system without the damper is equal to f_n, that of the damper alone should be

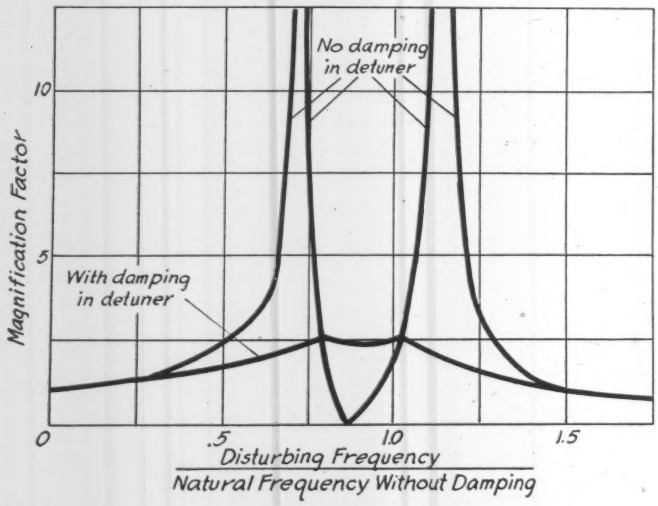

Fig. 57—Vibration amplitude of main mass, Fig. 56, when subjected to pulsating torque and equipped with a damper

$f_n/(1+I_{dt}/I)$. For example, if $I_{dt}/I=.2$ the damper frequency should be $f_n/1.2=.833\,f_n$. The response of a system, having these proportions, to periodic torque applied at the disk I is shown in *Fig.* 57. The curves for "no damping" indicate critical speeds at the two natural frequencies, which occur at .732 and 1.14 times the frequency of the untuned system (*Fig.* 56) respectively. Effect of the apparent and inherent damping in a unit of the type shown in *Fig.* 54 is to reduce the amplitude greatly, as shown in *Fig.* 57.

In the system just described, the amplitude of vibration at an applied frequency close to that for which the damper was tuned (.833) is zero with no damping. If the shaft speed and hence the frequency remains constant at this value the undamped absorber completely eliminates vibration. At other shaft speeds the applied frequency changes in proportion and departs from the tuned frequency of the damper. To meet special conditions in variable-speed drives a "tuned pendulum" type of absorber provides the same type of control but is effective at any speed (Reference 5). Used extensively in radial aircraft engines, the absorber is illustrated diagrammatically in *Fig.* 58*a*. It consists of a weight (which, incidentally, is part of the counterweight required to balance the pistons and connecting rods of the engine) attached to the crank cheek in bifilar pendulum fashion. The actual construction shown in *Fig.* 58*b* is practically equivalent to the schematic arrangement but involves pure rolling motion only, with correspondingly low friction.

When a periodic torque is applied to the crank the pendulum swings back and forth with an amplitude depending upon the frequency and magnitude of the applied torque. As it does so the reaction torque which it exerts on the crank is comparable to that of the detuner flywheel already discussed, the maximum effectiveness occurring at the natural frequency of the pendulum. Because the pendulum rotates with the crank, however, its natural frequency is a function of the normal acceleration due to rotation, rather than to gravity, and is directly proportional to speed. Referring to *Fig.* 58*a*, the equation for natural frequency is $f_n=(\text{rpm}/60)\sqrt{q/l}$ vibrations per second. In application the pendulum is tuned to a frequency corresponding to the major disturbing frequency in the applied torque. For example, in a 9-cylinder engine there are 9 firing impulses to each two revolutions so the absorber is tuned to a frequency 4½ times the engine speed.

In the series of articles of which this is the conclusion an attempt has been made to cover, in brief, those aspects of vibration likely to concern designers of many types of machines. In handling specific problems the designer will do well to take advantage of the engineering "know-how" of the manufacturers of special equipment such as vibration measuring and recording instruments, mounting units and materials, couplings, dampers, etc. In addition, the increasing trend toward lighter weights and higher

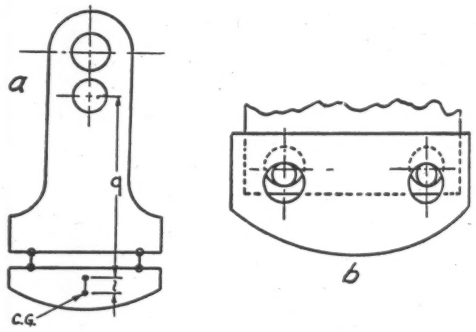

Fig. 58—Pendulum-type damper controls torsional vibration on aircraft engines. View at left illustrates principle while view at right shows actual design

speeds, with the accompanying vibration tendencies, makes it increasingly necessary for designers to acquaint themselves with the broader aspects of the subject through systematic study of references such as those listed at the end of this and the preceding article.

MACHINE DESIGN is pleased to acknowledge the cooperation of the following in the preparation of this article: The Falk Corp. (*Figs.* 46, 53, 54, 55. 56 and 57); Fawick-Airflex Co. Inc.; Lord Manufacturing Co. (*Fig.* 52); and Wright Aeronautical Corp. (*Fig.* 58).

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Standardization and Simplification

STANDARDIZATION is distinctly a creative job. It might be defined as the art of determining and establishing in use the best design, quality, method or process for performing a desired function.

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By pursuing these two movements we arrive at Interchangeability, which results in conservation of materials and manpower, or negatively in the elimination of waste. The sum total spells Progress.

Let us find out what forces are with us and what forces are against us as we strive after the goals of universal standardization and complete simplification in practice.

We are faced with four great enemies. The first is Ignorance; the second is Fear; the third is Selfishness; and the fourth is one for which I have a kind of sneaking regard. It is hard to give him a name. The best I can think of is Individuality.

On the other hand we have fighting for us three great allies. The first is Common Sense; the second is Economy; and the third is that intangible thing which, again for lack of a better name, I call Universal Brotherhood.

We need not spend much time in analyzing our allies. But what about our enemies? They must be sized up very carefully.

The first one—Ignorance—is not so formidable. We are wearing him down right now. We have been wearing him down, for years back, by ordinary hard work. He is not an aggressive type of enemy. He is merely an obstruction that has to be whittled away to make room for progress.

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The second enemy—Fear—is much more dangerous. It takes just such a war as the present one to bring into sharp focus the extent to which Fear, in the past, has blocked the progress of universal standardization.

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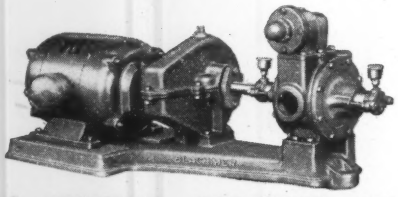

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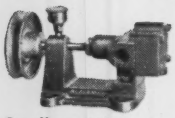

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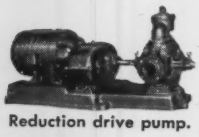

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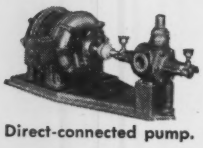

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complete field of engineering science, the situation b comes really serious.

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Three Thousandths of an Inch

Surely we could fight for an acceptance of commo standards among the English-speaking nations of th world, leaving the universal problem to our childre and our grandchildren. Is it not a frightful commentary on the common sense of the people on this North Amer ican continent that when the war broke out there wa not a single gun or a single round of ammunition commo to the U. S. and the Canadian forces? The Canadians made, and still make, .303 cartridges. The United State made, and still make, .30 cartridges. How in all the earth do we reconcile these miserable three one-thou sandths of an inch, and all the implications that follow in the wake, with our joint glowing tributes to the un defended frontier and the hundred years of peace and fellowship?

The third enemy—Selfishness—is the brother of Fear. They work as a team. When this war is over, once more we will be engaged on the interminable job of trying t steal an unwarranted proportion of the other fellow's business. And then is when selfishness comes in for his innings. He whispers to the British industrialist, "Be careful now, if you start adopting universal standards you will jeopardize your foreign trade, which is tied up now with your peculiar trade practices." Our friend and ally, common sense, may be whispering in the other ear, "But don't you see, it will widen your market and everyone's market."

Let's leave them whispering. Personally, I am a little pessimistic on the outcome. We travel on to the last enemy—that rather likeable fellow, Individuality.

Individuality Argues His Case

He can be dealt with, if you recognize clearly his dual personality. His only argument is that you and I and every free-born citizen demand that we continue free to express our egos in the way we desire; that we do not want to be standardized, that standardization and regi mentation are almost synonymous. He will ask you what you are fighting for. He will quote you the Four Free doms. In fact, he will try to get you all confused.

The answer is quite clear. No one wants to see ma terial production in this world so standardized that we cannot tell whether we are walking down Fifth avenue, New York, or the Champs Elysees in Paris. The aesthetic things in life will never be standardized, but in the utili tarian things behind the scenes, what a field there is for progress; what a field for elimination of waste and use less duplication!—*From a paper by J. B. Carswell, Presi dent of War Assets Corp. Ltd., presented at a meet ing in Toronto sponsored by the Affiliated Engineering and Allied Societies in Ontario.*

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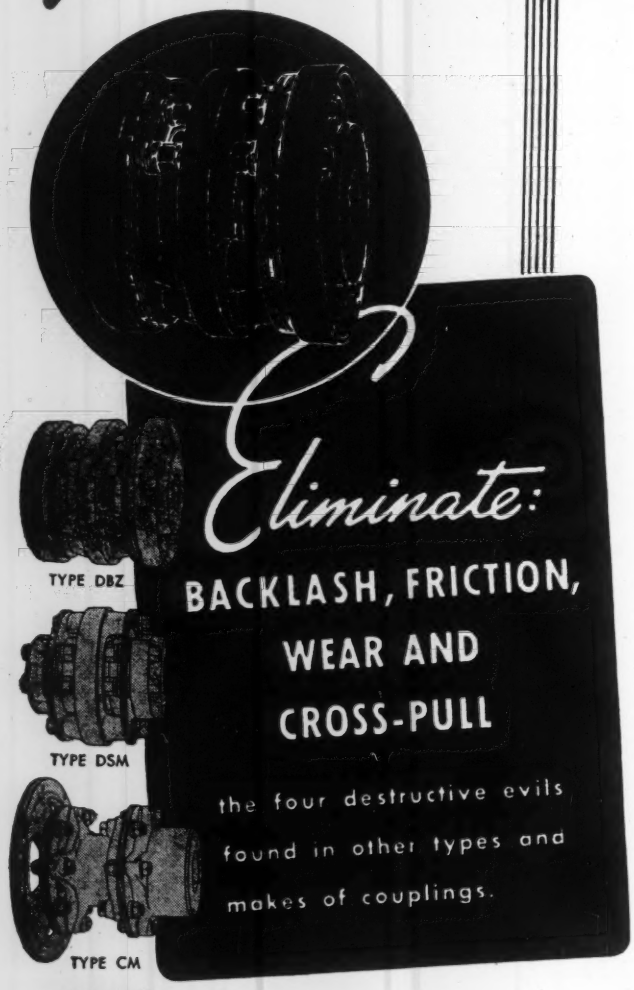

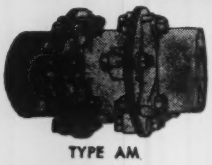

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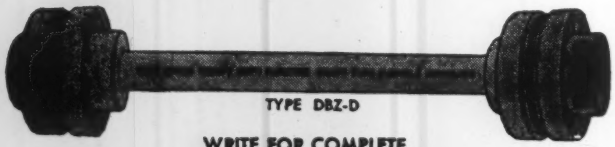

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Cylindrical Grinder

(*Continued from Page* 158)

plenished constantly and the overflow drains back to the main reservoir in the bed of the machine. As can be seen in the diagram a more or less locked control system between the throttle valve and each end of the dwell valve is maintained by the small reservoir.

Wheel Base Movement Rate Varies

The wheel base carrying the grinding wheel spindle generally is fed toward the work at right angles to the horizontal plane of the carriage and table movement. Although precisely coordinated with the preceding hydraulic arrangement, a different set of movements is necessary for the proper functioning of the machine consistent with desired high production. During the cycle occurring when grinding a piece of work, the grinding-wheel base must advance rapidly to the point of contact between the grinding wheel and work, then fed slowly until the work is ground to size and thereafter be returned quickly to its original position. Because of the variation of work diameters the hydraulically controlled motions must be flexible enough to start grinding at any position of the grinding-wheel base after the rapid infeed is expended. To do this a hydraulic reset arrangement is provided so that the complete stroke (.060-inch or less) of slow feed is available. This reset, accomplished hydraulically, is completed at the end of each grinding cycle and will be discussed later.

To start the wheel-spindle base forward the rapid infeed lever is moved forward manually to the position shown in the circuit diagram. Oil coming through the relief valve enters the rapid infeed valve from which it is directed to the right-hand end of the rapid-feed cylinder, pushing the piston to the left. This piston is adjustably attached to a threaded shaft which meshes with a small worm gear as shown in *Fig.* 4. As the helix angle between the screw and the worm gear is a locking angle the two pieces move in unison thereby advancing the wheel base toward the work. As the far end of this shaft contacts a stop button the slow feed is brought into play. This slow feed can be accomplished in two ways; continuously or automatically, the latter being intermittent.

Effecting Continuous Slow Feed

Taking into consideration the first, namely, continuous feed, the oil is metered through a needle valve to the slow-feed cylinder, the piston of which can be seen to the left in *Fig.* 4. This piston works at right angles to the rapid-feed piston and shaft, has a movement of 2-7/16-inches and is integral with a rack, the latter meshing with a pinion on the rapid-feed shaft. Cross movement of the slow-feed piston rotates the pinion and the screw thread. The thread acts as a feed screw and advances the wheel base forward slowly for a maximum of .060-inch. In this instance the worm gear, because it is locked above by another worm and worm wheel, acts as a half nut and advances the wheel base on the slide

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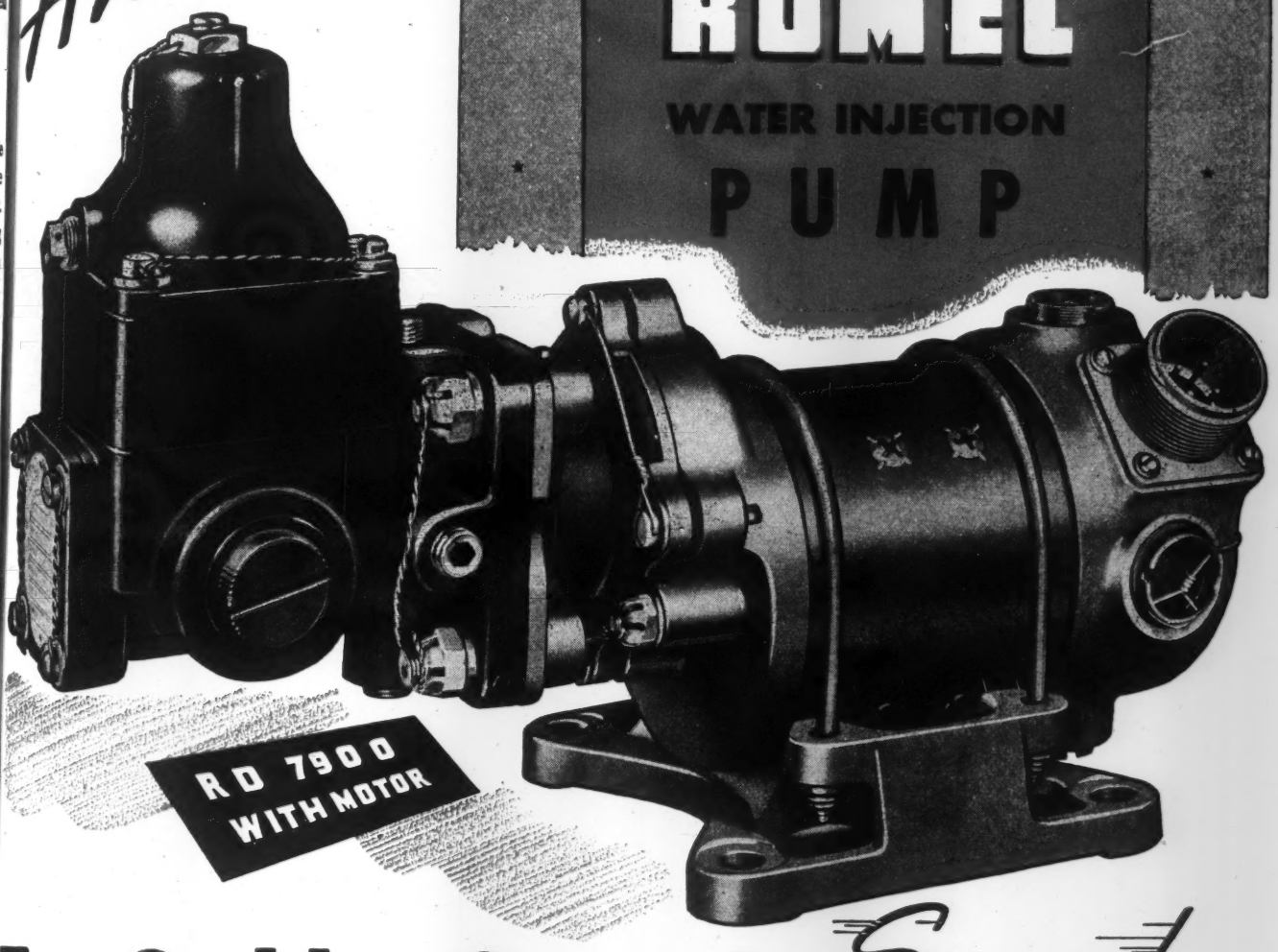

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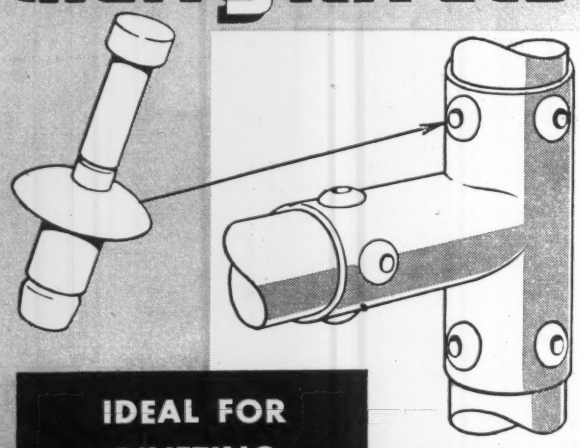

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LOS ANGELES, CALIFORNIA

thereby feeding the wheel gradually into the work.

When it is desired to feed intermittently, that is a each end of the table traverse, the continuous wheel feed valve is closed, thereby bringing into play the automatic-feed throttle valve. As the reverse valve operates the hydraulic fluid flows to one end of the automatic-feed valve shown at the bottom of the traverse control valve in the diagram. At each reversal of the table a small quantity of oil is forced into the slow-feed cylinder thus advancing the piston intermittently a slight and preset amount which in turn rotates the feed screw for movement of the wheel-spindle base.

Adjusting Slow-Feed Travel

While the maximum distance of slow-feed travel is .060-inch as the rack moves 2 7/16 inches, both of these dimensions can be reduced by adjusting a graduated knob (shown above the filter in *Fig.* 5). This is the only hydraulic adjustment not located within the operator's reach as he stands in his operating position. However, this adjustment need be made but once for each setup depending upon the amount of stock to be removed from the work.

To prevent shock at the several positive-stop stations of the wheel base, a cushioning arrangement is provided. As the wheel base nears the end of its rapid infeed it is required to ease up gradually to a positive stop. At the pinion end of the rapid-feed piston is a small triangular, tapered groove, which as it passes the exhaust outlet, gradually chokes off the exhausting fluid. At the same time the fluid passes through an adjustable restrictor or cushioning valve (see circuit diagram). This cushioning effect takes place at the end of the stroke either way.

When the rapid and slow-infeed cycle is completed and the work has been ground to size, not only does the wheel base withdraw quickly, but the thread and rack and gear arrangement resets itself preparatory to the next complete grinding cycle. The fluid is at this time directed into the upper end of the slow-feed cylinder. This drives the piston against the preset positive stop, meanwhile rotating the pinion by the movement of the rack. The pinion has turned the screw which in turn has forced the small worm wheel acting as a half nut back for its full stroke of .060-inch or less.

Taking Up Backlash

During both the rapid and slow-infeed movements, particularly the latter, the backlash in the several mechanisms must be taken up before the grinding wheel contacts the work. This is accomplished by a retard cylinder, the piston of which is engaged by a lug on the wheel base. The cylinder pushes against the restricted exhaust oil, the restriction being adjustable.

Both the table and carriage unit and the wheel-base move on flat and V-guides, being lubricated by the same fluid that powers the hydraulic system. The oil runs through ⅛-inch tubing to these ways. While the ball valve at the left (upper right, diagram prevents drainage when the machine is idle, the weighted ball on the right regulates not only excess pressure but also excess volume of oil reaching the guides.

Wright

CYCLONE 18 ENGINES

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BOEING B-29 SUPERFORTRESS . . .

THE AMERICAN TUBE BENDING COMPANY

is proud to be chosen by the makers of Wright Engines (Both Wright Aeronautical Corporation and its licensee) as principal supplier of the intricate Intake Pipes shown in the photograph above. In addition this company makes a large part of the Oil Lines and Bent Tubular Parts for fuel injection systems used by these giants of the air. **NIPPON YOUR NUMBER IS NEXT!**

Do you have a copy of the American Tube Bending Book?

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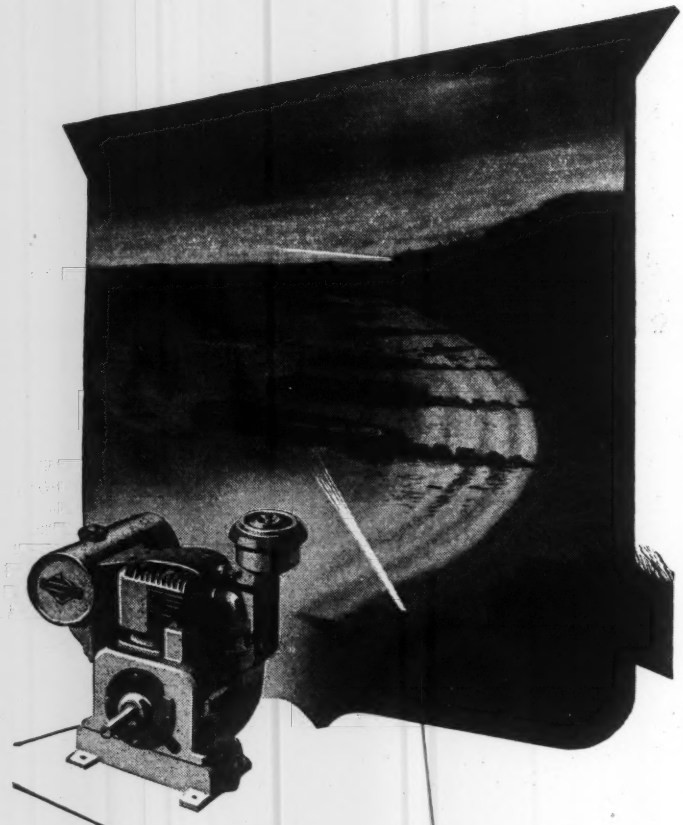

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From newly established positions, portable beacon units guide and warn supporting ships and aircraft. Their electric generating plants are powered by rugged, quick-starting Briggs & Stratton engines —another one of many vital war services by hundreds of thousands of Briggs & Stratton engines.

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Briggs & Stratton leadership in design, engineering and precision manufacture is backed by the performance record of more than TWO MILLION Briggs & Stratton engines—and a quarter-century of *continuous* production of *"air-cooled power."* You can profit by this experience in your plans for the future —whether you manufacture, sell or use power equipment. BRIGGS & STRATTON CORP., Milwaukee 1, Wis., U.S.A.

BUSINESS AND SALES BRIEFS

ELECTION of M. H. Corbin as a director of the company has been announced by Standard Varnish Works. Mr. Corbin, who had been manager of industrial sales at the New York plant for the past two years, has also been appointed vice president in charge of sales of both the New York and Chicago divisions.

♦

According to a recent announcement, Jack W. Forbes has been named sales manager of Wickwire Spencer Metallurgical Corp., Newark 5, N. J., recently formed subsidiary of Wickwire Spencer Steel Co.

♦

Formerly vice president and sales manager of Howell Electric Motors Co., M. J. Sandling has joined The Reliance Electric & Engineering Co. and will work under the general direction of J. L. Buell Jr., district manager in Detroit. Mr. Sandling will have his headquarters in the Pythian building, Kalamazoo, Mich.

♦

Western Automatic Machine Screw Co., Elyria, O., has announced the return of Robert Burch, sales representative, to Buffalo. Mr. Burch had been in Elyria, O., the past two years helping to expedite the plating of aireraft parts and other war materiel manufactured by the company.

♦

Addition of Frank Renner to the staff of sales engineers covering the Southern California territory has been announced by The Foxboro Co., Foxboro, Mass. Mr. Renner will make his headquarters at the Los Angeles office located at 2307 East Eighth street. Also announced is the addition of Robert Beers to the staff of sales engineers in the New York office at 420 Lexington avenue. Mr. Beers will cover the New York-New Jersey territory.

♦

Previously in charge of the Chicago office, Norman W. Slohm has been placed in charge of sales of aluminum to the steel industry by The National Smelting Co., Cleveland, and will make his headquarters at the main office in Cleveland.

♦

Change of name has been announced by The Black & Decker Electric Co., Kent, O. The organization, which manufactures fractional horsepower electric motors, will be known as The Lamb Electric Co. Ownership has been acquired by an investment group headed by the present officers of the company.

♦

R. B. Golling at 12065 Edgewater Drive, Cleveland, has been named representative in Ohio, western New York and western Pennsylvania for Bound Brook Oil-Less Bearing Co., Bound Brook, N. J. Representing the company in eastern Pennsylvania, southern New Jersey, Maryland, Delaware and

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Greater Resistance to VIBRATION

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THE ACRO ELECTRIC COMPANY
1311 SUPERIOR AVENUE CLEVELAND 14, OHIO

Virginia will be W. K. Swift at 159 West Berkley avenue, Lansdowne, Pa. Mr. Swift formerly had been located in Cleveland.

♦

Promotion of A. C. Kacher to manager of the Minneapolis branch has been announced by Westinghouse Electric Supply Co. Connected with the company for twenty-three years, Mr. Kacher had been apparatus and supplies salesman in Minneapolis. Also announced is the appointment of Robert Hills as central district stores manager with headquarters in Detroit. Mr. Hills became a member of the company in 1935.

♦

Moving from 664 North Michigan avenue to 230 East Ohio street, Chicago 11, has been completed by Barnes & Reinecke, industrial designers and engineers. Barnes, Reinecke & Rebholz, an associate company, has moved to the new location also.

♦

Purchase of a 155-acre plot of ground in Liverpool, N. Y., has been announced by General Electric Co. As soon as necessary materials are released by the government, the company plans to build a new plant to be used as headquarters for the electronics department.

♦

Edgar C. Brandt has been made assistant to the general manager of Crocker-Wheeler Electric Mfg. Co., division of Joshua Hendy Iron Works, Ampere, N. J. Before joining the company, Mr. Brandt had been connected with the Elliott Co. as vice president and general manager.

♦

Election of Walter A. Meyer, manager of dealer sales for Allis-Chalmers Mfg. Co., as president of the Multiple V-Belt Drive association has been announced recently. Prior to his election as president, Mr. Meyer had been vice president and chairman of the executive committee.

♦

Goodyear Tire & Rubber Co., Akron, O., has named Walter P. Hallstein Jr. as assistant manager of the belt sales department. Mr. Hallstein has been associated with the company since 1934.

♦

Promotion of Ralph W. Hisey to vice president in charge of all manufacturing and engineering of both the brush and machine divisions has been announced by The Osborn Mfg. Co., Cleveland. Vice president since 1935, Mr. Hisey has been connected with the company for more than thirty years.

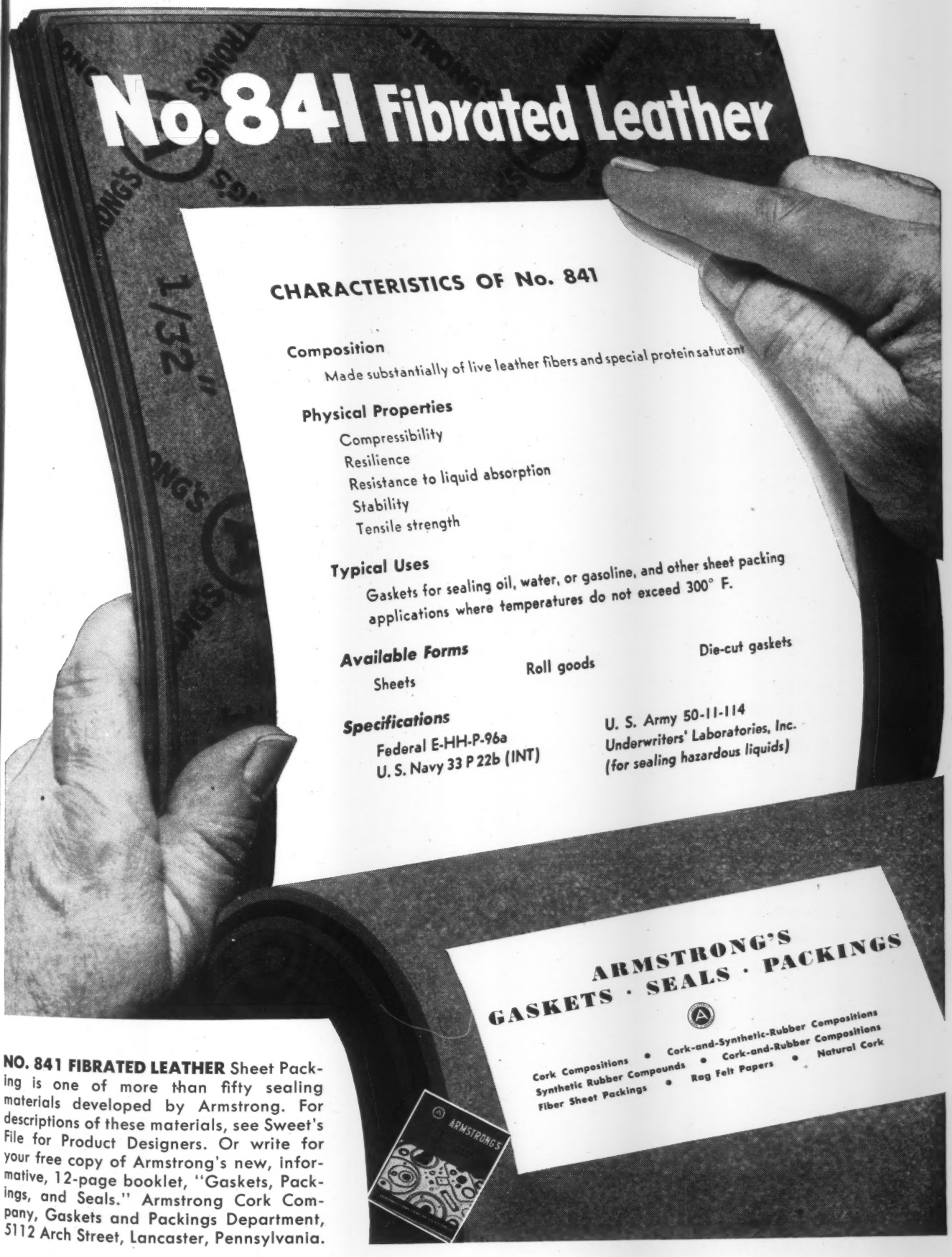
♦

Position of industrial manager of the Atlanta, Ga., branch has been given to Dave W. Choate by Minneapolis-Honeywell Regulator Co. and the Brown Instrument Co., its precision industrial instrument division. Succeeding Mr. Choate as industrial sales engineer of the Milwaukee branch of Brown Instrument Co. is W. S. Robards who has been connected with the company for eight years.

♦

Transfer of W. R. Persons to the factory and main office at Cleveland where he will carry out a special postwar planning assignment has been announced by The Lincoln Electric Co. Succeeding him as Pittsburgh district manager is J. S.

ARMSTRONG'S SEALING MATERIALS

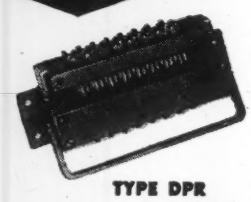


NO. 841 FIBRATED LEATHER Sheet Packing is one of more than fifty sealing materials developed by Armstrong. For descriptions of these materials, see Sweet's File for Product Designers. Or write for your free copy of Armstrong's new, informative, 12-page booklet, "Gaskets, Packings, and Seals." Armstrong Cork Company, Gaskets and Packings Department, 5112 Arch Street, Lancaster, Pennsylvania.

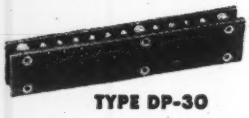
LOOK TO CANNON 'DP' CONNECTORS IN 1945

HERE ARE A FEW OF THE 'DP' CONNECTORS AVAILABLE *NOW* AND MANY NEW DESIGNS ARE COMING

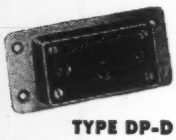
NEW applications of the exclusive Cannon Electric "DP" series of connectors have recently been extended from rack equipment in radio assembly to such uses as special centralized aircraft control on through to signal relay equipment.



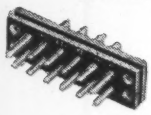
TYPE DPR



TYPE DP-30



TYPE DP-D



TYPE DP-P10

Several new "DP" connectors of strikingly new design will be released in 1945—testimony to the progressive engineering Cannon Electric incorporates into its products. Since Cannon Electric pioneered the aircraft electrical connector in 1932, this development process has gone steadily onward. Cannon is prepared to meet the demands of postwar electrical equipment.

Cannon Type DP Connectors cover a variety of rack, panel and bail-type fittings, carrying from eight to 135 circuits with amperage range from 10, 15, 30 and 40 in many varied arrangements, including coaxial contacts. All these and many other high quality electrical connectors are Cannon designed and manufactured.

For detailed engineering data on Type DP Connectors refer to the Cannon DP Bulletin. Write to Department A-107, Cannon Electric Development Company, 3209 Humboldt Street, Los Angeles 31, California.

CANNON ELECTRIC

Cannon Electric Development Co., Los Angeles 31, Calif.

Canadian Factory and Engineering Office:
Cannon Electric Company, Limited, Toronto

Representatives in Principal Cities—Consult Your Local Telephone Book

Roscoe who formerly had been Syracuse district manager. Succeeding the latter, in turn, is Paul James who had been district manager of the Rochester office, a position now filled by E. L. Smith.

♦

Ralph Wall has been named assistant sales manager of Pacific division, Bendix Aviation Corp., North Hollywood, Calif. He has been a member of the Pacific division sales department for the past six months, having served as laison sales engineer until his present appointment.

♦

Appointment of Garrett Supply Co., 3844 South Santa Fe, Los Angeles 11, as distributor for the Southern California-Arizona area has been announced by Carboloy Co. Inc., Detroit.

♦

Previously manager of branch sales in New York, Herman A. Everlien has been made general sales manager of the mechanical goods division, United States Rubber Co. Walter F. Spoerl, who held an executive sales position in the New York office, has been appointed merchandise manager. Both of these positions have been newly created.

♦

According to a recent announcement by The Clark Controller Co., the new address of the Cleveland district office is 635 Empire building, Cleveland 14.

♦

Rudel Machinery Co. Inc., Boston, has been named exclusive sales representative for Logansport Machine Co. Inc., Logansport, Ind., in the New England territory which includes Massachusetts, Maine, Vermont, New Hampshire, Rhode Island and Connecticut.

MEETINGS AND EXPOSITIONS

Dec. 11-13—

American Society of Agricultural Engineers. Fall meeting to be held at Hotel Stevens, Chicago. Raymond Olney, Box 229, Saint Joseph, Mich., is secretary.

Dec. 11-13—

American Society of Refrigerating Engineers. Fortieth annual meeting to be held at Hotel Pennsylvania, New York. David L. Fiske, 37 West Thirty-ninth street, New York, is secretary.

Jan. 8-12—

Society of Automotive Engineers Inc. Annual meeting and engineering display to be held at Book-Cadillac hotel, Detroit. John A. C. Warner, 29 West Thirty-ninth street, New York, is secretary and general manager.

Jan. 22-24—

American Society of Heating and Ventilating Engineers. Fifty-first annual meeting to be held at Hotel Statler, Boston. A. V. Hutchinson, 51 Madison avenue, New York, is secretary.

Jan. 30-Feb. 1—

Institute of the Aeronautical Sciences Inc. Thirteenth annual meeting to be held in New York. Additional information may be obtained from headquarters of the Institute at 30 Rockefeller Plaza, New York. Robert B. Dexter is secretary.

Feb. 26-March 2—

American Society for Testing Materials. Spring meeting to be held at Hotel William Penn, Pittsburgh. Robert Painter, 260 South Broad street, Philadelphia, is assistant to the secretary.

ENGINEERING
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WHEN LOOSE NUTS AND BOLTS *Are* FATAL

TO DEPENDABLE PERFORMANCE

It's A Job for

• "Everlocking" gives your assemblies extra *staying power.* Note the wide chisel edge construction on the enlarged EverLOCK Washer illustrated above. These chisel edges are forced into the contiguous faces of both work and nut by powerful spring tension . . . providing several times more area of resistance. The effects of vibration and strain are effectively counteracted. Speed of application permits substantial time and labor savings.

Wire, phone or mail your orders today.

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PROMPT DELIVERY ON MOST SIZES

*Ever*LOCK WASHERS

THE WASHER THAT HAS THE EDGE

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Some of the Advantages of Specifying "PERFECT" Oil Seals

1 They stop objectionable and wasteful lubricant leakage.

2 They prevent the entrance of dust and moisture into the bearing housing.

3 They increase bearing life and save bearing maintenance.

4 They reduce operating cost.

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6 They are small, compact and rigid.

7 They require no attention after installation.

8 They are inexpensive.

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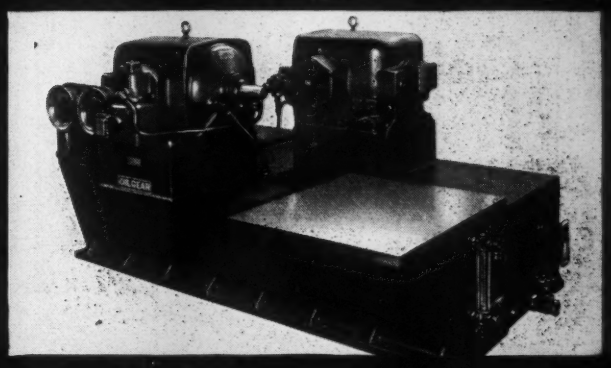
Economical Oilgear Radial Rolling Piston power units are used to charge stationary and portable catapult power plants to catapult planes at flying speeds in something over 100 feet. Besides high linear speed obtainable over a wide range, acceleration and/or deceleration are controlled, power can be stored during idle period.



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ARE YOU TRYING TO:

1. Apply large forces through long... or short... strokes at variable speeds?
2. Obtain automatic work cycles, variable speeds in either direction... with or without preset time dwell?
3. Apply large forces through continuous or intermittent reciprocating cycles at constant or variable velocities?
4. Obtain extremely accurate control of either position or speed of a reciprocating member?
5. Apply accurately variable pressure either static or in motion?
6. Closely synchronize various motions, operations or functions?
7. Apply light... or heavy ... forces at extremely high velocities through either long or short distances of travel?
8. Obtain continuous automatic reversing drives at constant R.P.M. or over a wide range of speed variation?
9. Obtain accurate remote control of speed and direction of rotation, rates of acceleration and/or deceleration?
10. Obtain constant horsepower output through all or part of a speed range?
11. Obtain automatic torque control?
12. Obtain accurately matched speed of various rotating elements?
13. Obtain constant speed output from a variable speed input?
14. Obtain full preset automatic control, elimination of problems of shock, vibration, etc.?

You Need Oilgear!

JUST ANOTHER EXAMPLE OF OILGEAR'S AMAZING ABILITY TO SOLVE THE PROBLEMS OF UNIQUE POWER TRANSMISSION

There is hardly any limit to the applicability of Oilgear Fluid Power. In catapulting heavy airplanes from the decks of carrier escorts, Oilgear not only furnishes the tremendous power required to accelerate the load from zero to flying speed in a few seconds but it accumulates this power with comparatively small, standard units while each plane is being maneuvered into position. *You* can use units of this type on other installations where tremendous power or high velocity is required intermittently, as in die casting machines, braiding and knitting machines, riveting presses, etc. Or if your machine power or transmission requirements lie far afield, they are almost certain to be met... better, more economically... in any of the scores of other functions Oilgear Fluid Power provides. Just as war industry built upon peacetime knowledge, so today shrewd designers are adopting the lessons learned in war. Put *your* problem up to Oilgear engineers; see if their solution isn't what you've been looking for. Do it *now*... THE OILGEAR COMPANY, 1305 West Bruce Street, Milwaukee 4, Wisconsin.

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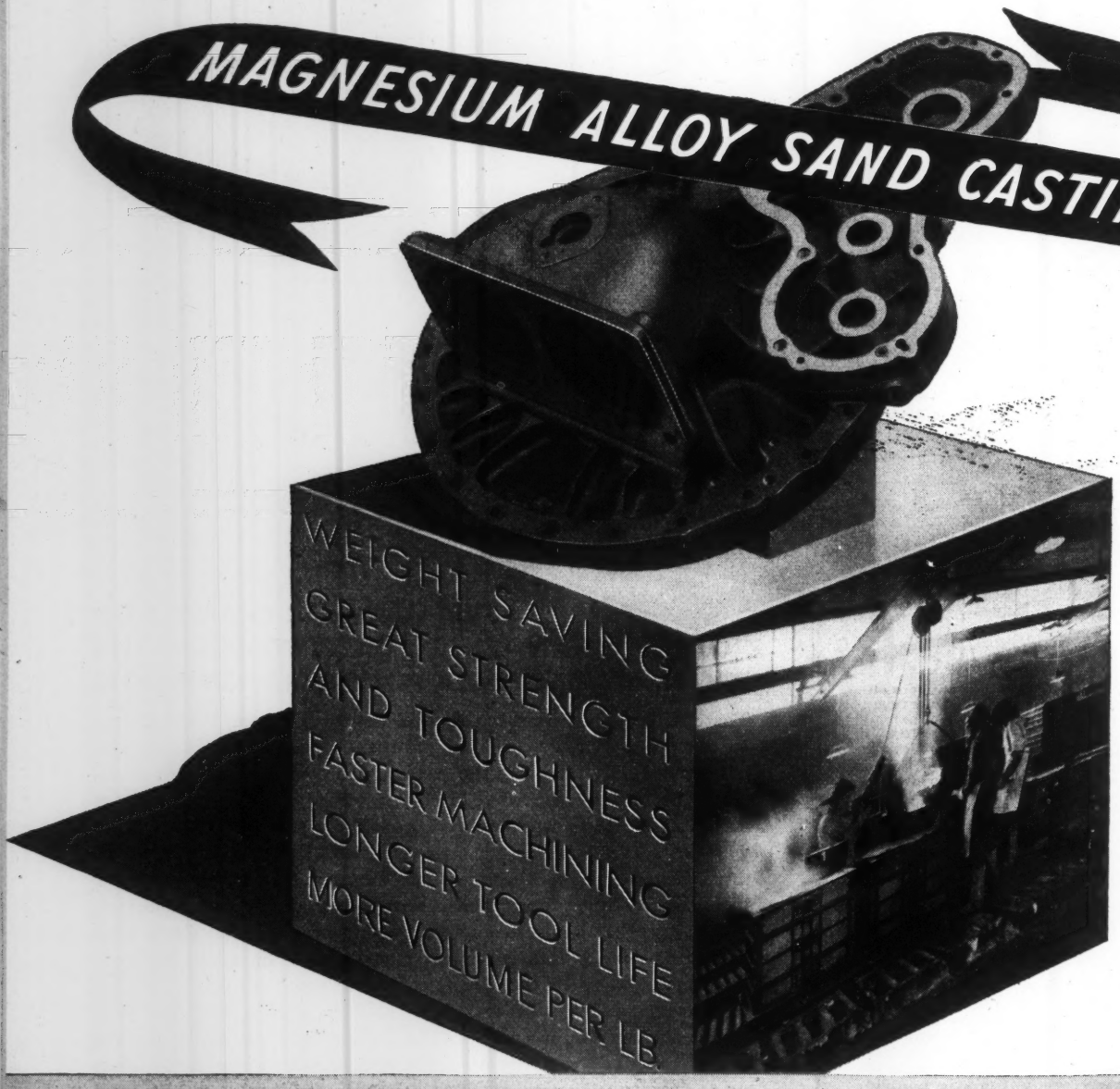
MAGNESIUM ALLOY SAND CASTINGS



NEWS FLASH

Magnesium is now available for Civilian Products—the War Production Board having removed all restrictions.

NOW THAT all restrictions on the use of magnesium for civilian products have been removed, an avenue of modernization of equipment and devices is open to all.

The use of Hills-McCanna Magnesium Alloy Castings offers the design engineer the means of eliminating useless weight from any reciprocating parts of machinery and equipment, saving power and energy, as well as reducing vibration and increasing rigidity. Machining costs are reduced, tool life is prolonged and you get more volume per pound.

Buses, trucks, trailers, portable tools and the many manually handled devices, all benefit through the weight-strength ratio which Hills-McCanna Magnesium Alloy Castings offer.

Our large modern foundry is equipped to handle your requirements to exactness and at low cost. Engineering aid covering all aspects of fabrication and utilization is yours for the asking.

Write for this 52 page ... gineering Manual giv... physical, mechanical ... working characteristics ... Hills-McCanna Castings

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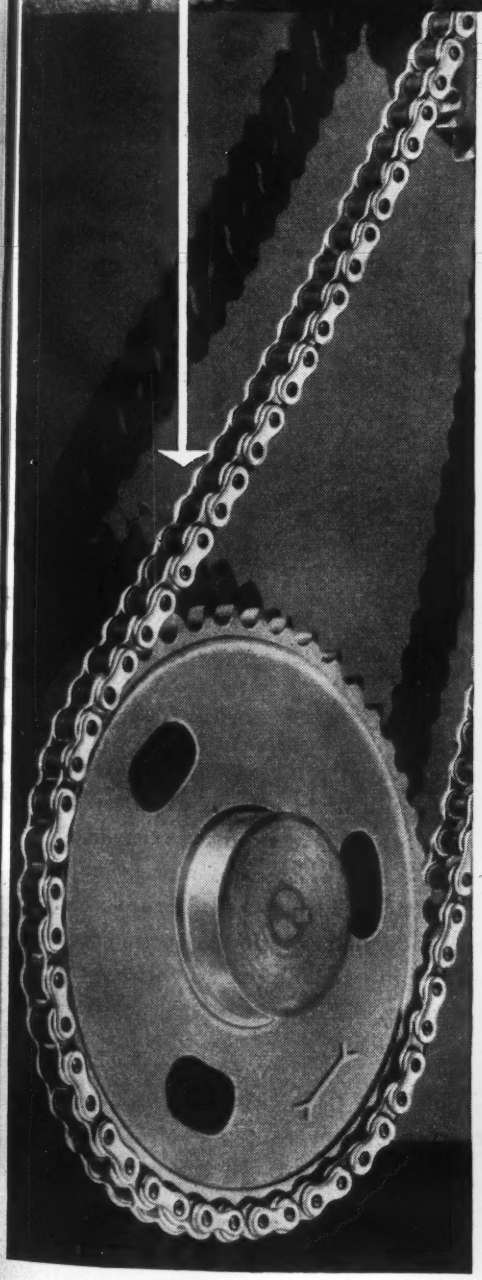
READYING THE "BIG INCH"



A tough Job licked with the help of

LINK-BELT *Silverlink* ROLLER CHAIN!

Every minute this queer-looking contraption travelled 18 ft. along America's famed "Big Inch" pipe line, removing dirt, rust and mill-scale, applying a coat of primer and wrapping the pipe with a protective coating.

To do a vitally important job—and a tough, dirty job, thoroughly and quickly, the WKM Company developed this pipe-line cleaning machine, and selected Link-Belt Silverlink roller chains for the gruelling task of driving three separate operations. A drive of double width, 1" pitch chain operates the cleaning head at 400 r.p.m., a 1" pitch single chain, drives the priming head (through a reduction gear) at approximately 100 r.p.m., and 1" pitch single width chain, drives the crawler wheels which move the machine along the pipe.

Out in the open, exposed to weather, dirt, and scale, these chains are demonstrating their ability to "take it," at the same time they are delivering power efficiently and without calling for any special attention.

Link-Belt Silverlink Roller Chain may be the answer to *your* problem of economical, efficient, flexible application of power. Every r. p. m. is unfailingly delivered on long or short centers, either direction, over several shafts if need be. Link-Belt's unsurpassed experience and manufacturing facilities assure you complete satisfaction. Send for Data Book 1757 on Silverlink Roller Chain.

LINK-BELT COMPANY

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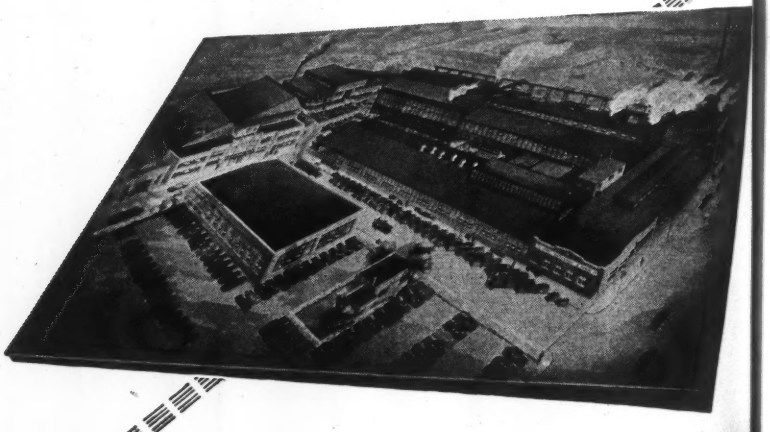
LINK-BELT *Silverlink* **ROLLER CHAINS**

One purpose . . .

the IMPROVEMENT of Metals

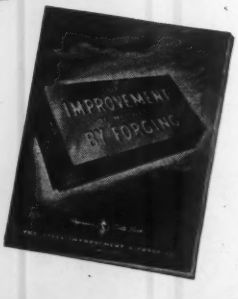


Continuous fibre flow throughout the structure of this unit is essential to provide the physical properties necessary to meet exacting service requirements.

by Forging

In forging the design of a part is usually a governing factor in developing the metal quality required to meet a given service condition. Designing especially for forging makes possible the utmost IMPROVEMENT OF METALS BY FORGING. The more simple, straightforward designs often permit a high rate of production. Throughout 31 years of forging production experience, our engineers have employed all the known forging techniques to forge many so-called impossible-to-forge designs. Ask one of our forging engineers about how to improve product performance with forgings.

Reference Data Booklet presents many new ideas on forgings and their applications in many different kinds of equipment. Copies available to engineers, metallurgists and executives.



DROP FORGINGS

THE STEEL IMPROVEMENT & FORGE CO.

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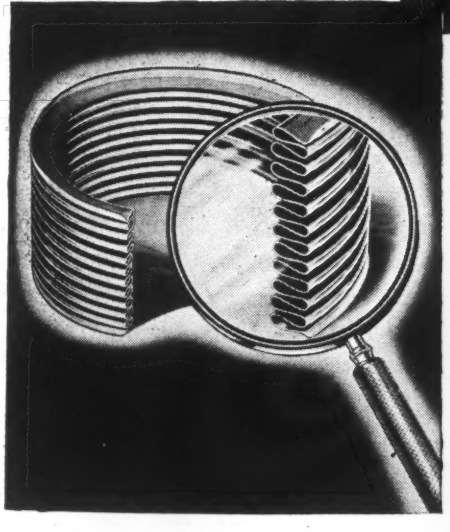

NOTE UNIT CONSTRUCTION. **Bellows is a one-piece expansible and collapsible member. Side-walls are deeply folded or corrugated as pictured above. No seams or solder.**

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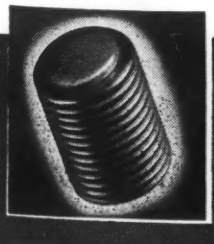
HOUR AFTER HOUR . . . day in, day out . . . a bellows proves a tireless worker *if it fits the job.*

Actually, there's only one best type and size for a particular application . . . the bellows that is engineered to meet all conditions encountered in actual usage.

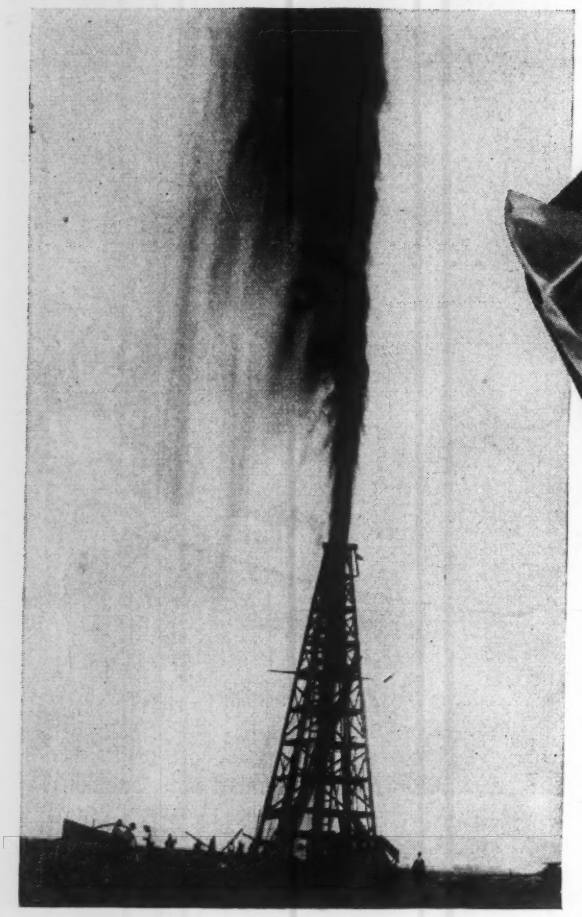
That is why much care should be taken when selecting a bellows . . . why our engineers insist upon exact data covering every phase of the working conditions under which each bellows is to operate. With these facts at hand they can assure the dependable performance for which Bridgeport Bellows are famous.

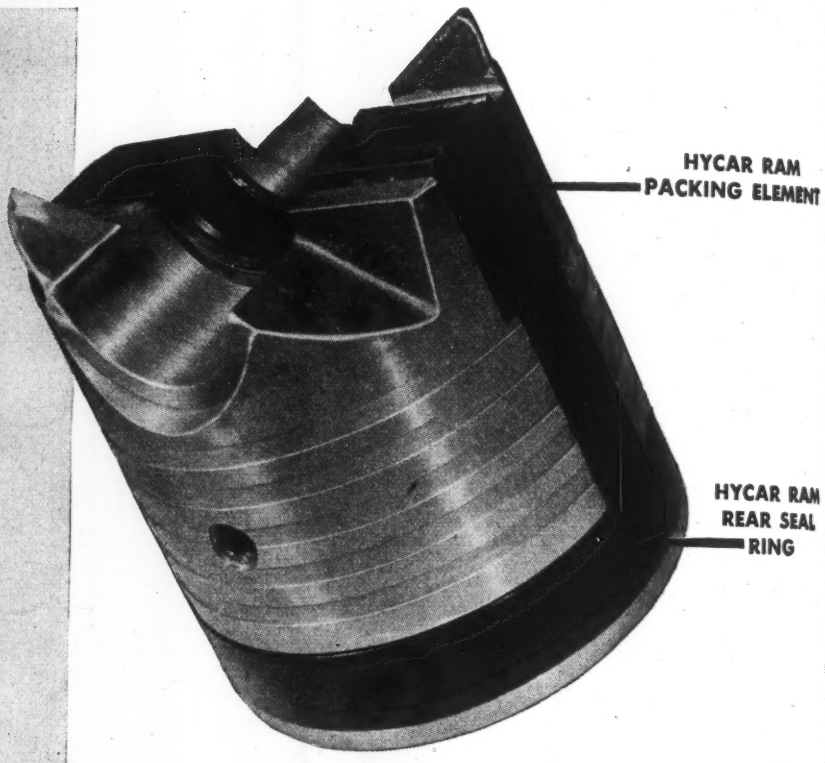
Why not consult Bridgeport now regarding your present or post-war bellows requirements? Catalog XK-100, full of valuable information, will be sent upon request.



Bellows Assemblies . . . Bellows . . . Bellows Devices

BRIDGEPORT THERMOSTAT COMPANY, INCORPORATED—BRIDGEPORT 1, CONN.





HYCAR RESILIENT PACKINGS PREVENT COSTLY OIL WELL "BLOWOUTS"

Properties which make this possible have many applications in all industry

WHEN an oil well like the one in the picture "blows out", chances are that expensive tools and machinery will be ruined, oil will be wasted, the well will be useless, lives may be lost. That's why, a few years ago, a "blow-out preventer" was developed. It fits around the drill pipe at the top of the well, ready to go into action if the drill hits a high pressure zone deep down in the ground. When that happens the preventer closes around the pipe and makes a tight seal against pressures as high as 5000 p.s.i. The seal then has to be maintained—even when the pipe is being rotated while adjustments are being made—for 6 to 9 hours.

Hycar synthetic rubber was selected for the resilient sealing element—and for good reasons. Hycar is able to provide the *right combination* of properties needed for this job—oil and gas resistance, abrasion resistance, ability to stay resilient. These and other properties of Hycar synthetic rubbers are listed in the box at the right. They tell why men throughout industry are learning that Hycar is the right material for pump and valve packings, grommets, diaphragms, vibration dampeners, hose and scores of other industrial applications. *Hycar Chemical Co., Akron 8, Ohio.*

Check These Superior Features of Hycar

1. **EXTREME OIL RESISTANCE**—insuring dimensional stability of parts.
2. **HIGH TEMPERATURE RESISTANCE**—up to 250° F. dry heat; up to 300° F. hot oil.
3. **ABRASION RESISTANCE**—50% greater than natural rubber.
4. **MINIMUM COLD FLOW**—even at elevated temperatures.
5. **LOW TEMPERATURE FLEXIBILITY**—down to —65° F.
6. **LIGHT WEIGHT**—15% to 25% lighter than many other synthetic rubbers.
7. **AGE RESISTANCE**—extremely resistant to checking or cracking from oxidation.
8. **HARDNESS RANGE**—compounds can be varied from extremely soft to bone hard.
9. **NON-ADHERENT TO METAL**—compounds will not adhere to metals even after prolonged contact under pressure. (Metal adhesions can be readily obtained when desired.)

Hycar

Reg. U. S. Pat. Off.

LARGEST PRIVATE PRODUCER OF BUTADIENE TYPE

Synthetic Rubber

Free—write for your copy of the new pocket-size Hycar Glossary of commonly used synthetic rubber terminology.

ALL THESE FEATURES

1. Full-range, stepless speed control
2. Constant speed under changing load
3. Full torque can be provided... even at low speed
4. Smooth, fast, current-limit acceleration

FROM A-C POWER

You Get Them When You Use THY-MO-TROL DRIVE

● Yes, you get all the desirable characteristics of d-c shunt motors and still operate on a-c power.

A Complete Drive—Thy-mo-trol drive is a complete equipment, its d-c motor operating from your a-c circuit. From a single, compact control station, the drive is started, stopped, and reversed, *and the speed adjusted.* Acceleration is electronically controlled. The motor is fully protected, and is stopped quickly by dynamic braking.

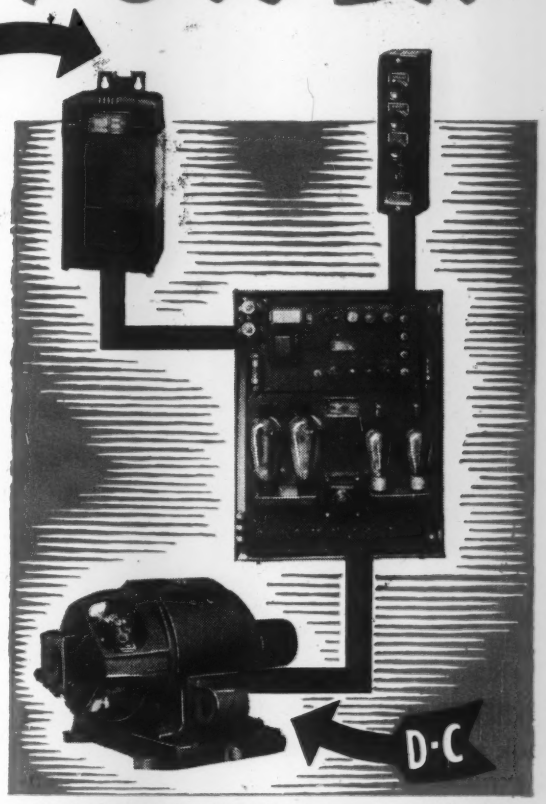
Standard drives can be obtained in ratings from 1/8 to 20 hp—higher or lower, if needed.

How to Buy Thy-mo-trol Drive

Just give our nearest G-E office complete information about your requirements—nature of the load, speed range, horsepower, etc. Our engineers will select the right Thy-mo-trol drive to give you exactly the operating characteristics you want.

Buy all the BONDS you can—
and keep all you buy

GENERAL ELECTRIC



THY-MO-TROL DRIVE is easy to install. These four compact units—d-c motor, electronic panel, compact control station, and small power transformer—make up the complete drive.

Learn more about Thy-mo-trol today

GENERAL ELECTRIC COMPANY, SECTION E676-172
SCHENECTADY 5, N. Y.

Please send me a copy of Bulletin GEA-4025, which tells what Thy-mo-trol will do and how it works.

NAME.....

COMPANY.....

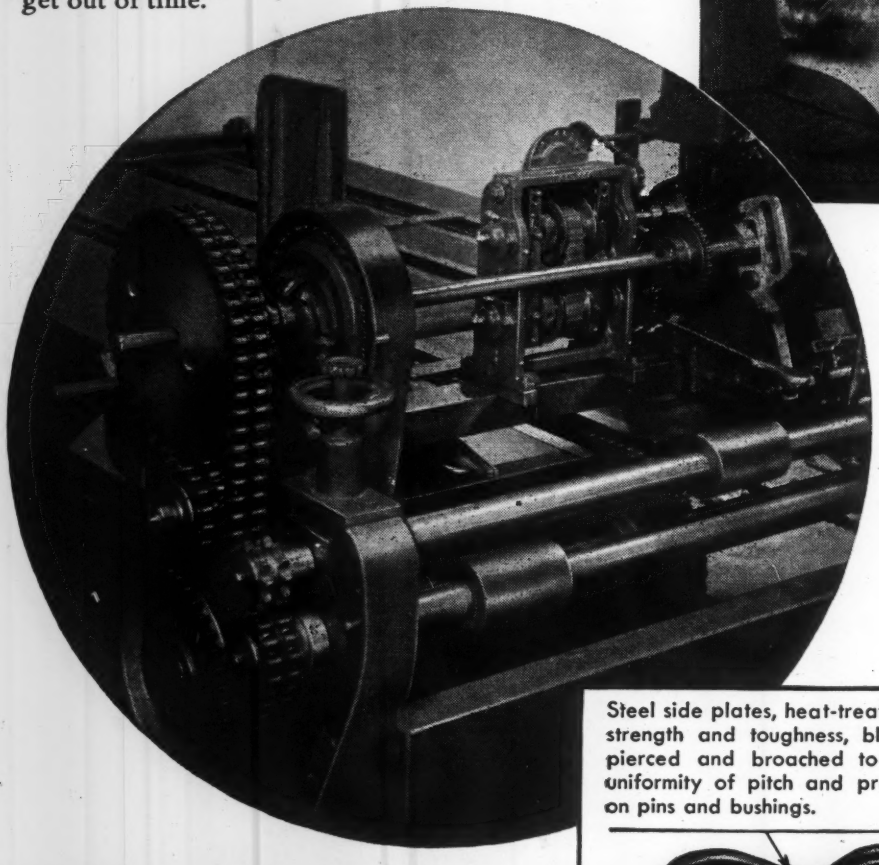
ADDRESS.....

.....

676-172-8890

IT TAKES A "FIRM GRIP" FOR ACCURATE TIMING

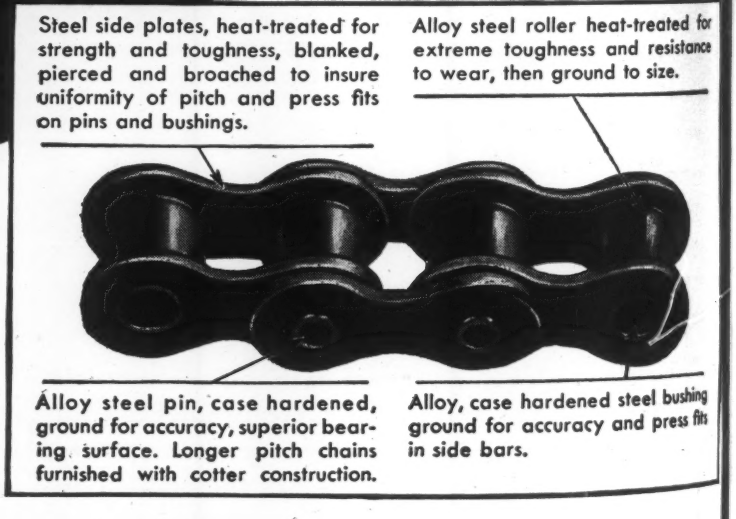
① WHEN YOU NEED SPLIT-SECOND TIMING, you'll find that Rex Roller chain belts can deliver the goods. For, the way these smooth-running chains take a firm grip on sprocket teeth, it's impossible for a machine to "get out of time."



② TIMING IS IMPORTANT on this tap ing machine. It tapes boxes as they ar formed from corrugated board. A functions . . . conveying, transmittin power and timing of various oper tions must be perfectly co-ordinate That's why Rex Roller chain belts ar used. They don't slip . . . wear i negligible.

③ HERE'S WHY THEY'RE SO GOOD! Take a good look at these links. Rex Roller chain belt is a product of the highest quality workmanship and materials. Note how accurately the link is formed. For high speed drives, compactness, quiet operation and high efficiency, this chain is "tops." Made in manufacturer's standard sizes, you can get it in single, double or multiple strands for every type of service.

* * *



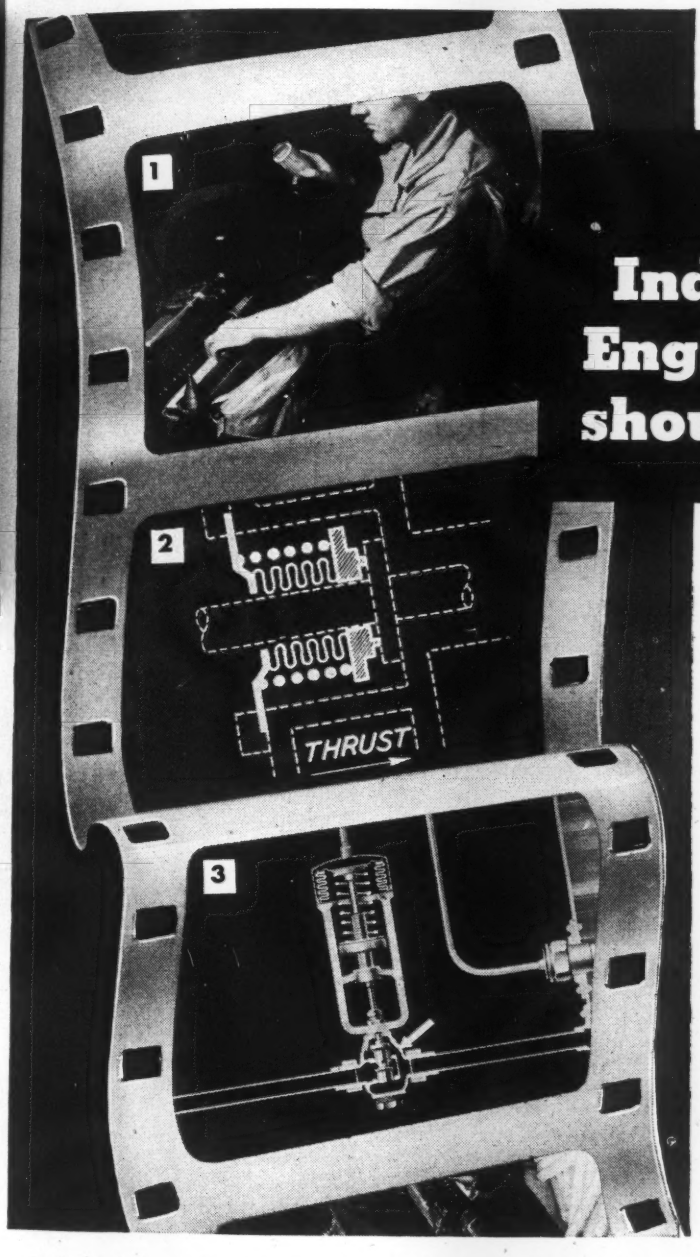
Rex Roller chain belts are the answer to any problem involving the positive transmission of power or timing of operations. The Rex Man can help you with your chain belt application problems. And, for engineering data, ask for the 768 page catalog No. 444. Chain Belt Company, 1643 West Bruce Street, Milwaukee 4, Wisconsin.

REX CHAIN BELTS

More than 2000 sizes and types for the positive transmission of power, timing of operations and conveying of materials

CHAIN BELT COMPANY OF MILWAUKEE

Rex Chain Belt and Transmission Division, Rex Conveying and Engineering Products Division, Milwaukee 4, Wis. · Baldwin-Duckworth Chain Belt Division, Springfield 2, Mass., Worcester 3, Mass.



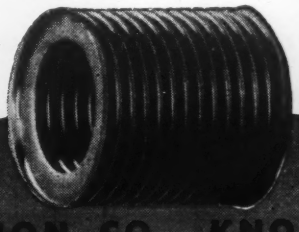
Every Industrial Executive, Engineer and Designer should see this picture

1. A specially designed hydraulic machine forms metal bellows from one-piece tubes.
2. Fundamental applications of bellows are shown in animation . . . may suggest how you can profitably employ Sylphon bellows.
3. This portion of the film explains the operating principle of various types of temperature controls.

SIMPLE as bellows are, words often fail to show the limitless design possibilities inherent in these versatile metal diaphragms. Too often many engineers have assumed that bellows only had application in a few fields, when actually they have been successfully applied to scores of designs in dozens of different industries.

"*The Story of Metal Bellows*" is an interesting and informative sound film, vividly showing the basic application characteristic of a Sylphon Bellows. It shows just how a bellows converts pressure and temperature changes into controlled mechanical movement, and demonstrates graphically how this movement is harnessed to perform innumerable tasks.

This picture is one of the most thought-provoking industrial films ever produced. We are sure your organization will find it stimulating. Let us know when it will be convenient to have this 28-minute sound film shown to your group, at no cost to you. 16 MM or 35 MM film available.

FULTON  **SYLPHON**

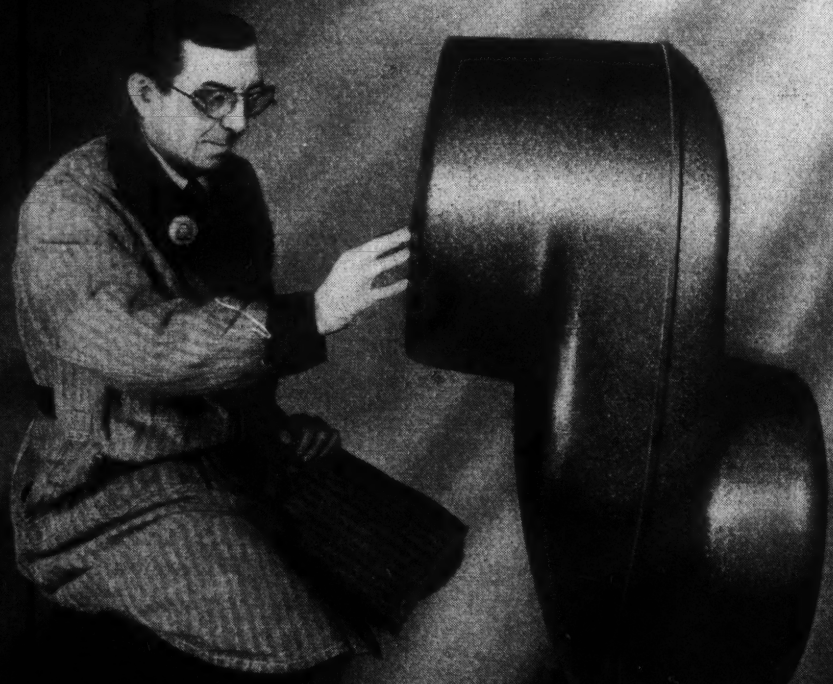
TEMPERATURE CONTROLS — BELLOWS . . . BELLOWS ASSEMBLIES

THE FULTON SYLPHON CO., KNOXVILLE 4, TENNESSEE

Canadian Representatives, Darling Brothers, Montreal

LADISH

CONTROLLED QUALITY



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ARMY E NAVY

New techniques in producing heavy drop forgings give more latitude to designers. Our engineers are available now for consultation on your postwar products.

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CUDAHY, WISCONSIN • Milwaukee Suburb

VICTORY, first: THEN—

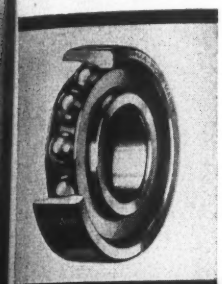
PRECISION BEARINGS FOR EVERY PURPOSE, INDUSTRIAL AND DOMESTIC

War's demands still call for all the output of the NORMA-HOFFMANN factory. But, already, far-sighted manufacturers are working with NORMA-HOFFMANN engineers on their designs for new and better peace-time products equipped with PRECISION BEARINGS.

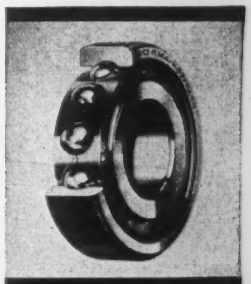
No "Re-conversion Problem" will hamper or delay NORMA-HOFFMANN post-war production. The moment peace is declared, all our vast facilities will be turned INSTANTLY to the production and prompt delivery of PRECISION BEARINGS for new and better domestic appliances and for new and better tools for industry.

Our Field Engineers, in all our District Offices, are ready to work with YOUR designers. Avail yourself of their experienced counsel NOW—without obligation, and of course in strict confidence. *Write for the Catalog—Today.*

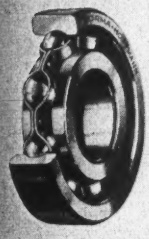
TO WIN THE WAR: WORK—FIGHT—BUY WAR SAVINGS BONDS!



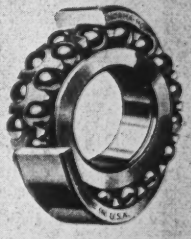
Separable (Magneto) Ball Bearing



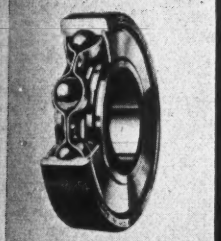
Litro ("CL") Composition Retainer Ball Bearing



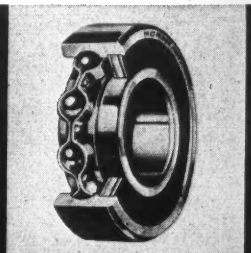
Single Row Ball Bearing



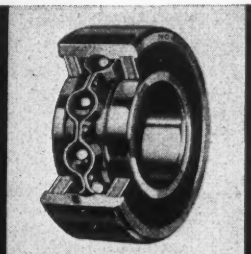
Double Row Self-Aligning Ball Bearing



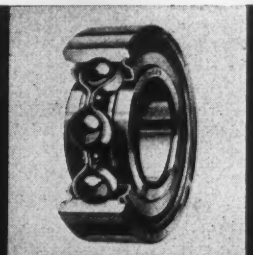
Shielded Type Single Row Ball Bearing



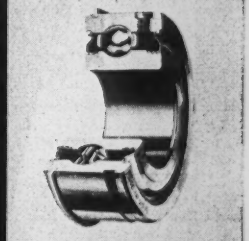
Single Felt Seal Ball Bearing



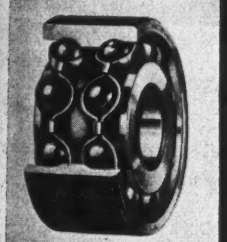
Double Felt Seal Ball Bearing



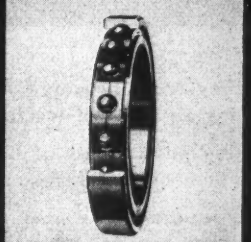
9000 Series (Feltless) Sealed Ball Bearing



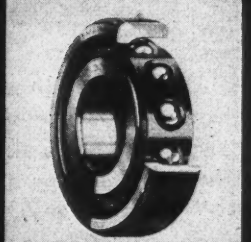
"Cartridge" Fully Sealed, Refillable Type Ball Bearing



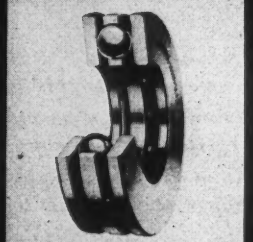
Double Row Ball Bearing



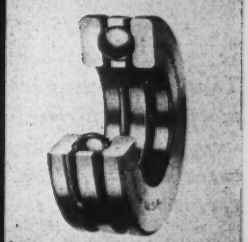
Extra Light Type Ball Bearing



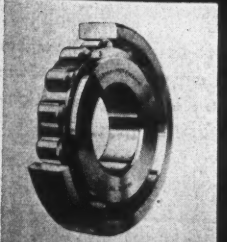
Angular Contact Ball Bearing



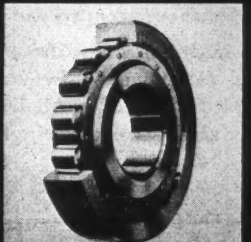
Extra Light Single Direction Ball Thrust Bearing



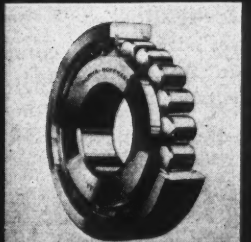
Single Direction Ball Thrust Bearing



Standard Cylindrical Roller Bearing

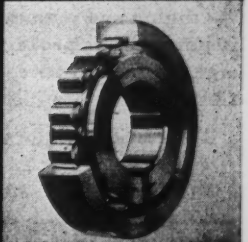


Type "E" Cylindrical Roller Bearing



Full Type (Retainerless) Cylindrical Roller Bearing

Extra Light Cylindrical Roller Bearing



Two-Lipped Cylindrical Roller Bearing

NORMA-HOFFMANN BEARINGS CORP'N. STAMFORD, CONN. *Founded* 1911

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SIGNED, SEALED AND READY FOR DELIVERY

That's the way packages emerge from this gum wrapping machine. With clocklike precision, the gum moves through the wrapping and sealing operations . . . every function perfectly coordinated . . . for Baldwin Roller Chain Belts time the operations, convey the packages and transmit the power.

LIKE so many other machines, where exact, split-second timing and smooth, jerk-free power transmission are vitally important, this packaging and wrapping machine takes advantage of the positive, efficient operation of Baldwin Roller Chain Belts.

The efficient performance of Baldwin Roller Chain Belts for all driving, timing and conveying functions makes them particularly suitable for all types of machines . . . in every industry.

Investigate the possibilities of Baldwin Roller Chain Belts for your jobs. They offer you these advantages:

1. **The ability to absorb shock loads.**
2. **Maintain constant speed ratios.**
3. **Compactness—less space per horsepower transmitted.**
4. **Cleanliness—do not collect dust and dirt.**
5. **Low maintenance—save time and money.**

For complete information on these better drives and how they can help you, call your Baldwin man or write for Baldwin Catalog M. Baldwin-Duckworth Division of Chain Belt Company, 320 Plainfield Street, Springfield 2, Massachusetts.

BALDWIN

ROLLER CHAIN BELTS

.OF *Self-locking* NUTS

The Stover Self-locking Nut is a beautiful example of precision manufacturing—but it "packs tremendous stamina." Sixteen precision machines are employed to make and test it—and to give the vibration-defying ***grip*** that spotlights the Stover nut among modern fasteners.

New in principle, the Stover Self-locking Nut represents a notable advance over other locking devices, especially in its employment of the natural elasticity of metal to give it holding power; its one-piece construction without complicated assembly, and its ability to lock firmly at any point on the bolt.

Evidence of the efficiency of the Stover Self-locking Nut multiplies rapidly in war production where, under Army-Navy specifications, it is giving exceptional resistance to the loosening effects of vibration.

For
BETTER AFTER-THE-WAR MACHINES

Every machine that vibrates will be a better machine if fastened with Stover Self-locking Nuts. Ask to have our representative call on you in relation to your post-war plans.

● *May we send you descriptive literature and samples?*

STOVER
SELF-LOCKING NUT
"IT WON'T SHAKE LOOSE"

STOVER LOCK NUT AND MACHINERY CORPORATION

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REPRESENTATIVES IN PRINCIPAL CITIES

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If you've ever had clutch trouble

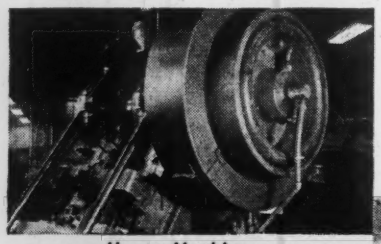
You'll want to know more about the clutch that controls power by air pressure—the Fawick Airflex Clutch.

It works without arms or levers or toggles or springs. No moving parts—nothing to lubricate or adjust. Low maintenance expense. Misalignment corrected automatically.

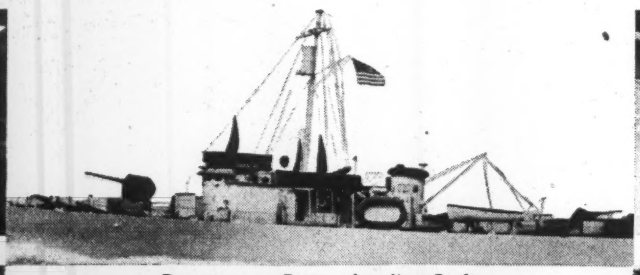
This new type of clutch just can't cause any of the conventional clutch troubles.

Proof? Certainly—in thousands of naval and merchant marine Diesel drives—in heavy duty drives for all kinds of machinery with tough jobs to do!

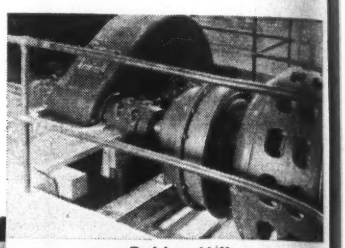
If you need a *trouble-free* Clutch, Brake or Flexible Coupling, our engineering department will be glad to make recommendations.



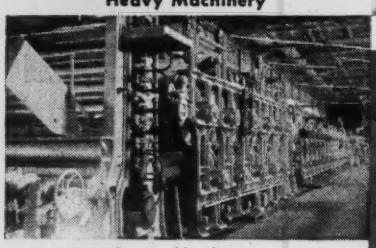
Heavy Machinery



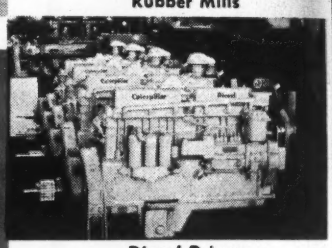
Destroyers — Tugs — Landing Craft



Rubber Mills

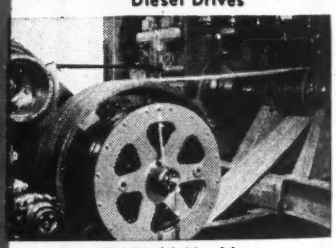


Paper Machines

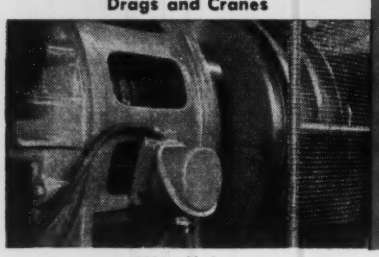


Diesel Drives

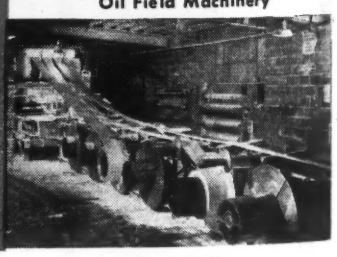
Drags and Cranes



Oil Field Machinery



Mine Hoists



Steel Mills

FAWICK AIRFLEX COMPANY, INC.

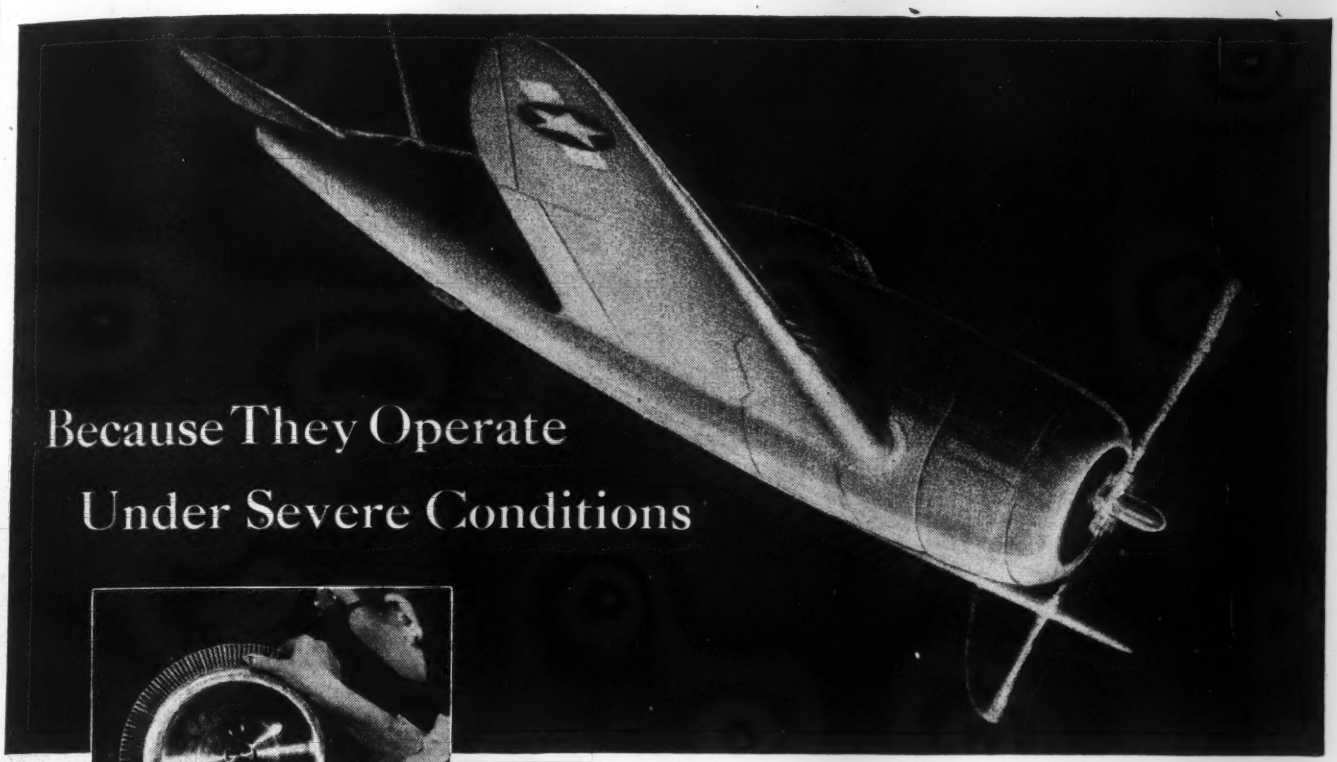
9919 Clinton Rd. · Cleveland 11, Ohio

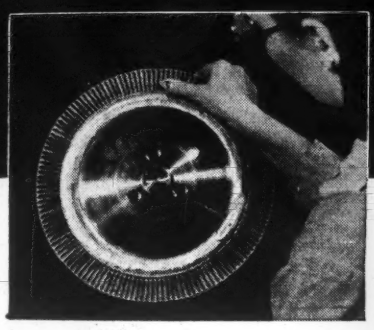
In Canada, **Renold-Coventry Ltd., Montreal, Toronto, Vancouver**

In Britain, **Crofts Engineers, Ltd., Bradford, England**

FAWICK *Airflex* CLUTCH

POWER CONTROLLED BY AIR





Turbosupercharger Buckets are made from a HAYNES STELLITE Alloy

• Buckets in the wheels of airplane turbosuperchargers are driven by the impingement of exhaust gases at 1,500 to 1,600 deg. F., and rotate at speeds so high that a ½-oz. bucket is subjected to centrifugal force of 750 pounds.

A HAYNES STELLITE alloy is used because it withstands the severe conditions of high temperature, corrosive gases, vibration, and centrifugal stresses over long periods of time. No other economically practical metal has been found for this service.

The same properties that make this HAYNES STELLITE alloy so essential in turbosuperchargers are also important in many other applications where severe conditions of heat and corrosion are encountered.

Consider HAYNES STELLITE alloys for those jobs where other metals fail. Our engineers will help you use them economically and efficiently. Write for further information.

Only HAYNES STELLITE Alloys Offer All These Advantages

1. They resist wear and abrasion.
2. They maintain their hardness even at red heat.
3. They retain their good mechanical properties at high temperatures over long periods of time.
4. They resist atmospheric corrosion and corrosive chemicals.
5. They take and keep a high polish.
6. They have a low coefficient of friction.
7. They are practically non-magnetic.
8. They can be supplied in the form of castings, small sheets, and welding rod.

HAYNES STELLITE TRADE-MARK

HAYNES STELLITE COMPANY

Unit of Union Carbide and Carbon Corporation

New York 17, N. Y. UCC Kokomo, Indiana

Chicago—Cleveland—Detroit—Houston—Los Angeles—San Francisco—Tulsa

RED-HARD, WEAR-RESISTING ALLOY OF COBALT, CHROMIUM, AND TUNGSTEN.

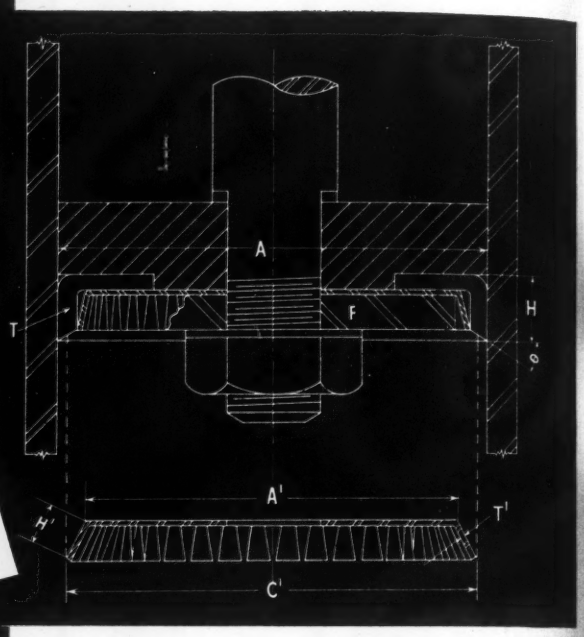
"HAYNES STELLITE" is a registered trade-mark of the Haynes Stellite Company.

GRATON & KNIGHT ENGINEERS

Present

PACKINGS POINTERS

No. 9



A = I.D. of cylinder or O.D. of cup packing
F = Follower plate
H = Height of cup packing
T = Thickness of cup packing
θ = Angle of bevel to horizontal
A′ = O.D. of expander at heel
C′ = O.D. of expander at lip in free position
H′ = Height of expander
T′ = Thickness of expander

EXPANDER FOR CUP PACKINGS

The use of an expander is good practice in any cup application — it keeps the packing in contact with the area to be sealed at all times. However in the majority of cases, the expander is not essential, and the extra cost of tooling up, fabricating and installing expanders is not warranted. The following cases do call for the use of expanders:

1. where particularly light, flexible cups are used.
2. where sudden pressure differentials occur.
3. where part of the stroke is manual and the cup is expected to suck in fluid to keep the cylinder full.

Expanders are also used in cases where the cylinder is slightly out of round or where there is a variation in diameter from one part of the cylinder to another. In some appliances, where long periods of stand-by are expected, expanders help to keep the cup in contact with the cylinder wall and provide instantaneous seal when called upon to operate.

FINGER-TYPE EXPANDER

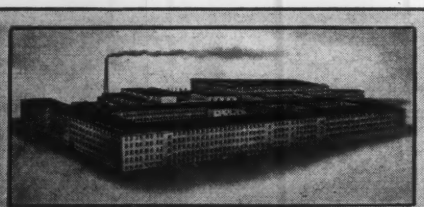
The most satisfactory type of expander is the finger-type. It is simple, efficient, easily installed, and requires only a slight change in diameter of follower plate (F). It is usually made of spring steel or phosphor bronze.

It is not possible to establish a set formula for the design of all finger-type expanders. Variations in equipment, size, pressures, materials are all factors that have a bearing on expander design. However, the following general rule is a safe starting point:

A′ = A–2T–2T′
C′ (in free position) = A–2T′
H′ = H–T
T′ = Optional (to be determined by the material used for the expander and the amount of tension required)

SPARTAN LEATHER PACKINGS

Graton & Knight's SPARTAN has highest resistance to abrasion and heat (withstands boil test), is unaffected by common pressure mediums, and will not dry out hard and brittle. It also has exceptional tear and tensile strength. When your design reaches the "packings point" —or when packings trouble occurs—call on G&K engineers.



World's Largest Manufacturer of Industrial Leather Products

SPARTAN ENGINEERED PACKINGS

GRATON & KNIGHT COMPANY

Worcester 4, GRATON AND KNIGHT Massachusetts

"Friction Fighters" in a HOT SPOT!

Middleby-Marshall travelling tray oven which uses eight cartridge type and two pillow block type Friction Fighter roller bearings.

Middleby-Marshall revolving tray type oven equipped with four pillow block Friction Fighter roller bearings.

LINK-BELT ROLLER BEARINGS

Help Roll Out the "Rolls"

● Bake oven service is hard on bearings. Sustained high temperatures make lubrication a tough problem, and uniform high quality of baked products demands uninterrupted operation. A builder of travelling and revolving tray ovens for bakeries in all parts of the continent, has chosen Link-Belt Friction Fighter Roller Bearings for this vital service. Scientific design and precision workmanship assure free rolling action under severe conditions of misalignment and varying combinations of thrust and radial load. Their rugged construction and high efficiency, make Friction Fighter Roller Bearings the logical choice for locations such as shown here. Data Book 1775-A will help *you* select the size and type for your tough bearing jobs. Send for a copy today.

LINK-BELT COMPANY

Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24, Toronto 8. Offices, Factory Branch Stores and Distributors in principal cities.

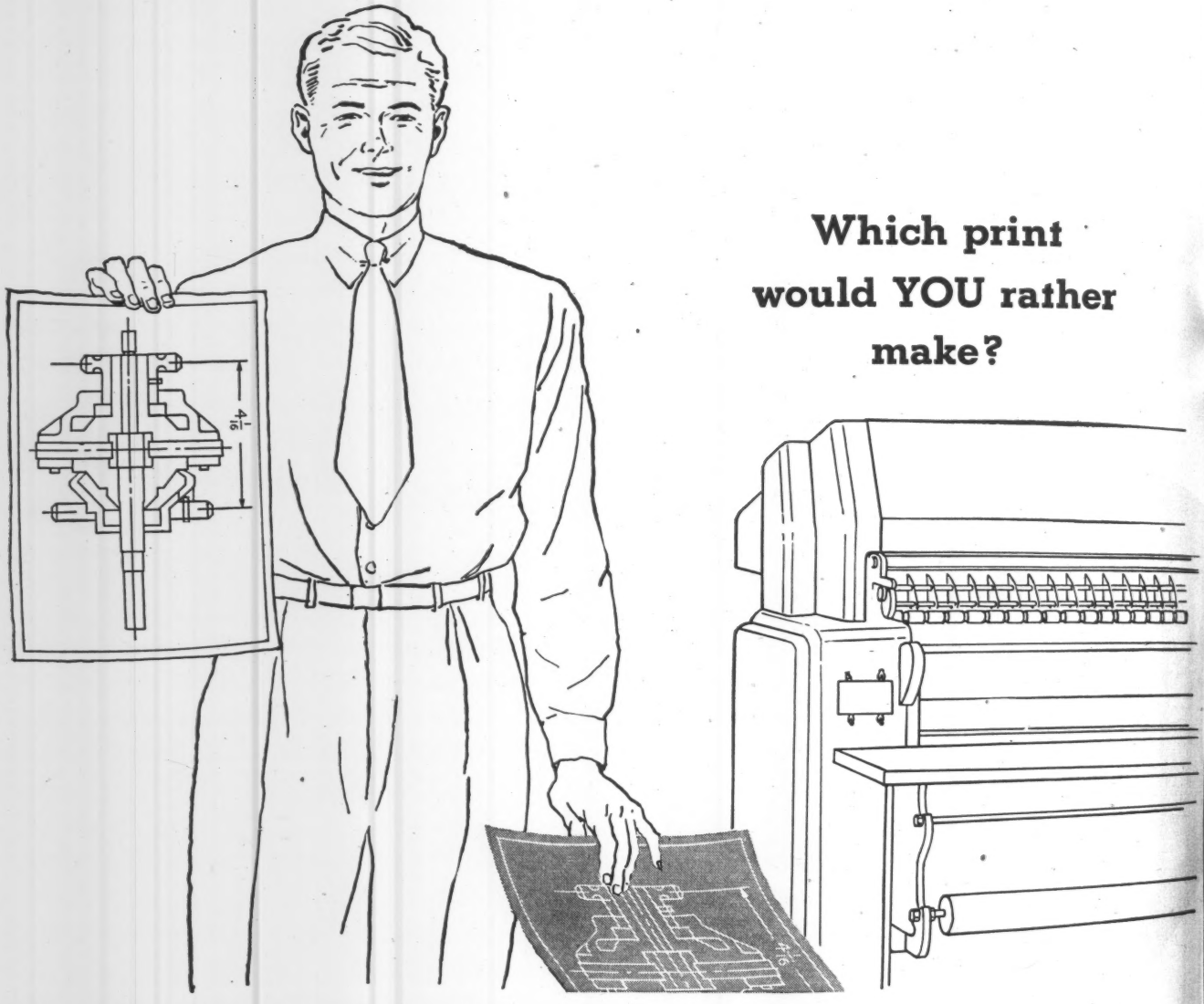
9688

LINK-BELT

THE SYMBOL OF QUALITY — LINK-BELT COMPANY

FRICTION FIGHTER BEARINGS

Roller and Ball Types



Which print would YOU rather make?

TRY your own hand at print making—and you'll soon see why operators prefer to make Bruning Black and White Prints rather than blue prints! For the BW process is simplicity itself. BW printing and developing machines are especially designed for the convenience of the operator. Controls are readily accessible—no reaching or stretching.

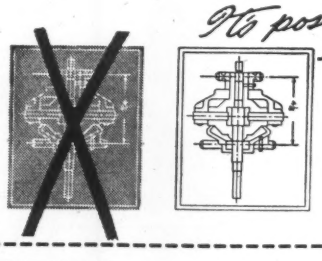
Count up the many other special advantages which BW Prints provide! Faster print production, for one thing, because BW Prints require no washing and are delivered ready for use. Easier reading, to help prevent errors in the shop or field. Easier checking, to speed production. The convenience and economy of producing prints on sheets cut to the exact size of your tracings. Much greater usefulness than blue prints.

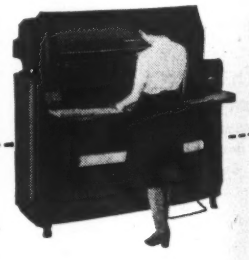
Whether you produce only a few prints a day or hundreds, there are BW machines to fit your needs —exactly. Write to Charles Bruning Co., Inc., 4700 Montrose Avenue, Chicago 41, Illinois, for new free booklet on BW Prints.

BRUNING "75-159-B" VOLUMATIC PRINTER-DEVELOPER

★ High speed production of prints—in large volume.
★ Only one operator required for big volume production.
★ Current consumption less than half of the operating amperage of an arc lamp machine of lower production.

It's positively right —in Black and White





BRUNING 2378-369 Since 1897

NEW YORK · CHICAGO · LOS ANGELES

Branch Offices throughout the United States. Everything for the Engineer and Draftsman.

Somewhere--here--

YOUR FLUID-CLEANING PROBLEM MAY COME TO A HAPPY ENDING

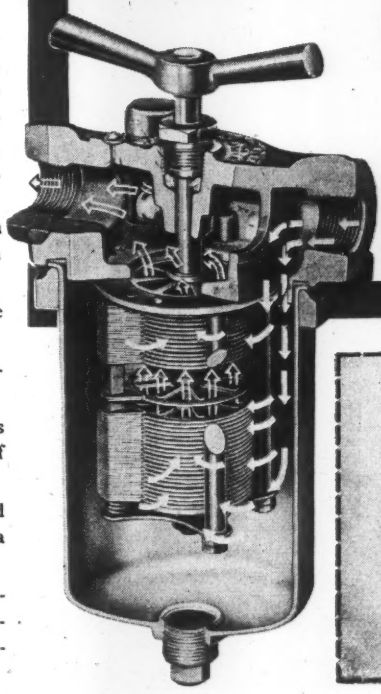
Do your plant records tell the wasteful story of uneven production? Do your fluid-handling operations require frequent shut-downs to clean or renew your straining equipment? If so, it will be worth your while to get an accurate picture of what Cuno *Filter-Fine* strainers can do for YOU.

Our free 32-page "QUICK FACTS" booklet tells how Cuno engineers have helped other engineers solve filtration problems in the fluid-handling systems of a dozen different industries. It cites specific cases, gives specific answers to specific questions. It is adequately illustrated with application diagrams and photographs. It may give you an idea or offer a solution to your own particular filtering problem.

"QUICK FACTS" shows the application of Cuno filters on: Aircraft Engines and Fluid-handling systems — Machine Tools — Gas and Diesel Engines — Turbines, Blowers and Compressors — Burners and Combustion Controls — Special Machinery and Equipment — Steel Mill Lubricating, Descaling and Cooling systems — in Metal Working Plants, Process and Food Industries. Also, it shows Cuno filters as applied to Paints, Coatings and Finishes.

Besides this, "QUICK FACTS" describes detailed construction of both types of Cuno filters — the *Auto-Klean* (illustrated right) and the *Flo-Klean*. It explains:

1. How the filter is cleaned without interrupting fluid flow.
2. How full flow is maintained with a single Cuno filter — no larger than other *partial-flow* types.
3. Why the cartridge need never be removed for renewal or cleaning.
4. How minimum pressure drop is obtained.
5. How an exclusive feature prevents clogging and avoids the build-up of sticky residue.
6. How the Cuno filter can be designed into a single machine, or applied to a centralized system.
7. How rigid, special-metal construction stands up under all kinds of conditions of abrasion, corrosion, erosion, pressure and temperature.



KEEP FLOW ON "GO" WITH

CUNO

THE "FILTER-FINE" STRAINER

CUNO ENGINEERING CORPORATION
212 South Vine Street
Meriden, Conn.

Please send me a free copy of QUICK FACTS

NAME .....

COMPANY .....

ADDRESS .....

Firm as Fixed Bayonets

. . . that's why

AMERICAN PHILLIPS SCREWS

drive Faster . . . Straighter . . .

and Cost Less to Use

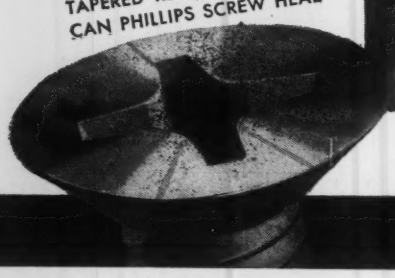
Like a bayonet fixed on a gun, an American Phillips Screw can't wobble, twist off, *or drive any way but straight*. For the engineered, tapered recess in the American Phillips screw-head *fixes* the 4-winged driver firmly in position . . . makes screw and driver an inseparable, straight-line driving unit until the screw is set up flush and tight.

This brings new ease and speed to production screw-driving . . . makes power drivers practical for any type of work . . . prevents accidents, scarred and rejected work, loss from split screw-heads. That's why over-all savings, in plant after plant, score American Phillips Screws at 50% or better, *over any other type of screw fastening.*

What's more, American Screw Company inspects *every* American Phillips Screw . . . for physical fitness of head, thread, and point . . . then checks shipments by automatic weigh-count to assure full value. Try American Phillips Screws on your own assemblies. You'll find they cost less because they help you produce much more.

AMERICAN SCREW COMPANY, PROVIDENCE 1, R. I.
Chicago 11: 589 E. Illinois Street *Detroit 2:* 502 Stephenson Building

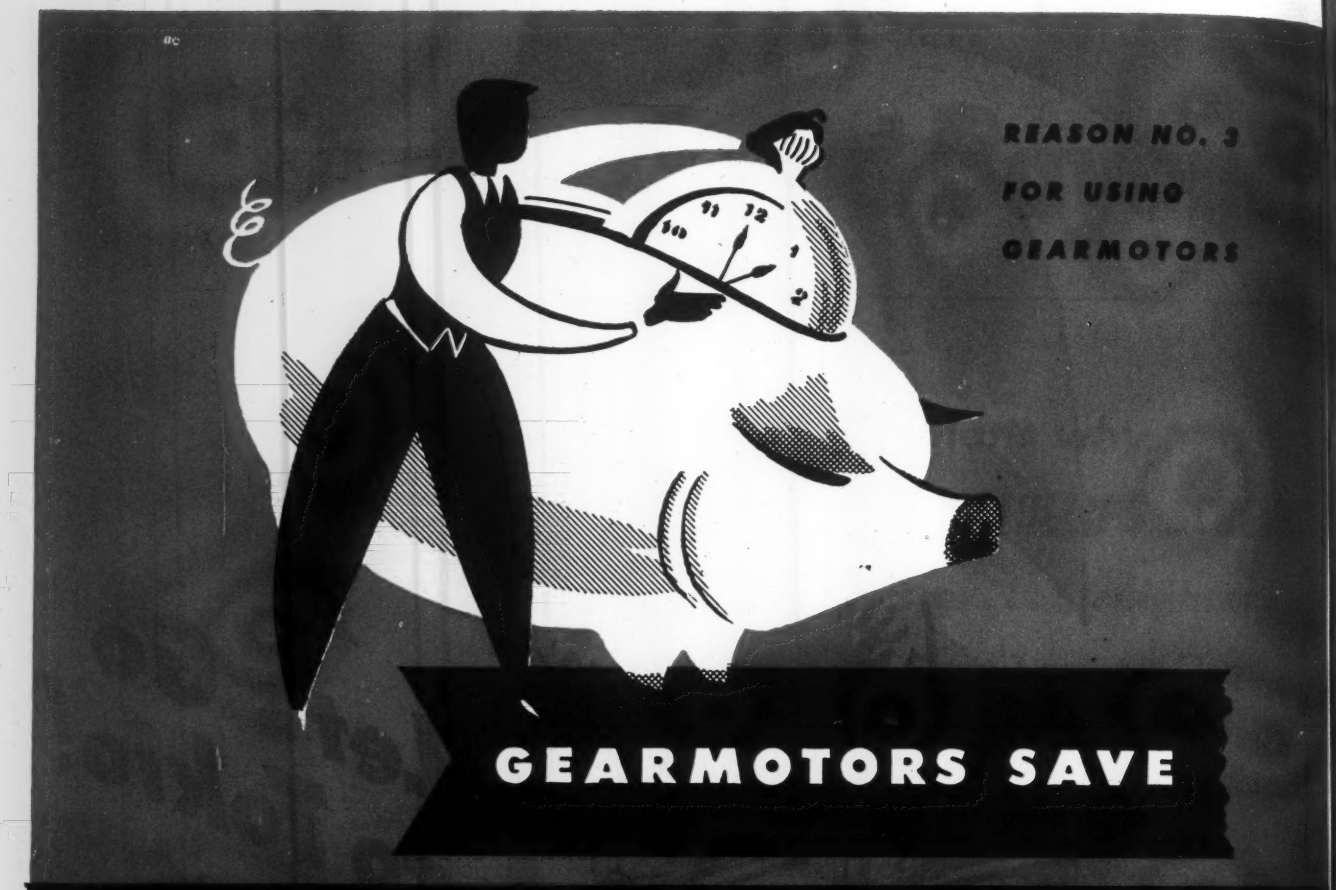
4-WINGED DRIVER CAN'T TWIST OUT OF ENGINEERED TAPERED RECESS IN AMERICAN PHILLIPS SCREW HEAD



AMERICAN PHILLIPS *Screws*

Put the Screws on the Japs . . . BUY BONDS!

Let's Go to Tokio!
6th
WAR LOAN
THE STANDARD TUBE CO.
Detroit 3, Michigan
STANDARD
Welded Tubing
Steel Forgings



INSTALLATION TIME AND EXPENSE

Gearmotors can be installed easily and quickly . . . with definite savings in time, trouble and expense. Once out of the crate, they're mounted and in operation with a minimum of time lost.

No other type of speed reduction is as simple to put into operation . . . because a gearmotor combines motor and speed reducer in *one* compact, easy-to-handle unit. It mounts on a single foundation, or directly on the machine to be driven, with no more expense than mounting a single motor. No complicated figuring is required . . . no time-consuming aligning and adjusting of many separate units.

Gearmotor installations save time because there are no belts, pulleys, open gears, guards or other pieces of equipment to be mounted or aligned separately. A recent typical installation of a splashproof gearmotor on a grain unloader saved $200 because the gearmotor made the housing and countershaft unnecessary.

Ask your Westinghouse representative about this and the many other basic advantages of gearmotors. All of these are discussed in detail in a new handbook, "Gearmotor Applications". Ask for B-3218. Westinghouse Electric & Mfg. Co., P.O. Box 868, Pittsburgh 30, Pa.

J-07223

REASON NO. 1—GEARMOTORS SAVE SPACE

REASON NO. 2—GEARMOTORS SIMPLIFY SELECTION, ORDERING, DELIVERY

One of a series sponsored by Westinghouse to promote the use of gearmotors

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

WHY INSTALL WESTINGHOUSE GEARMOTORS?

...here are 10 good reasons

1. FEWER PARTS TO WEAR. The simple, efficient, design employs a minimum of moving parts.

2. BPT "TOUGH-HARD" GEARS AND PINIONS. This exclusive Westinghouse heat-treating method "tough-hardens" teeth for maximum resistance to shock and impact—means longer wear.

3. USE ALL WESTINGHOUSE MOTOR TYPES—open . . . totally-enclosed . . . splashproof . . . explosion-proof—to meet changes in operating conditions quickly and easily.

4. INTERCHANGEABILITY OF PARTS between unit types reduces your parts' replacement stock by 40%.

5. HIGH EFFICIENCY of gearing parts assures full motor horsepower at output shaft . . . only 2% power loss for each gear set.

6. POSITIVE LUBRICATION of gears and bearings by automatic splash system reduces probable maintenance to twice-a-year change of oil.

7. EASY ACCESSIBILITY. Gearing parts can be readily inspected or easily removed to make gear ratio changes.

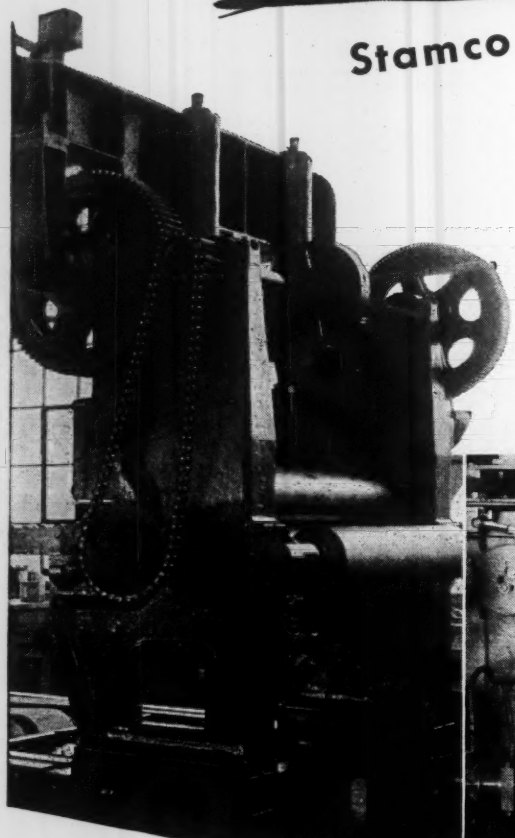
8. IMPROVED FOUNDATION STABILITY. Feet are under the gear case . . . placing support next to the gearmotor load. Each foot is reinforced by external ribs.

9. UNIT RESPONSIBILITY for design . . . manufacture . . . and service. Westinghouse builds both motor and the gears.

10. MEET A.G.M.A. STANDARDS. Westinghouse Gearmotors are specifically designed and built to meet A.G.M.A. standards . . . easy to order and match to the job.

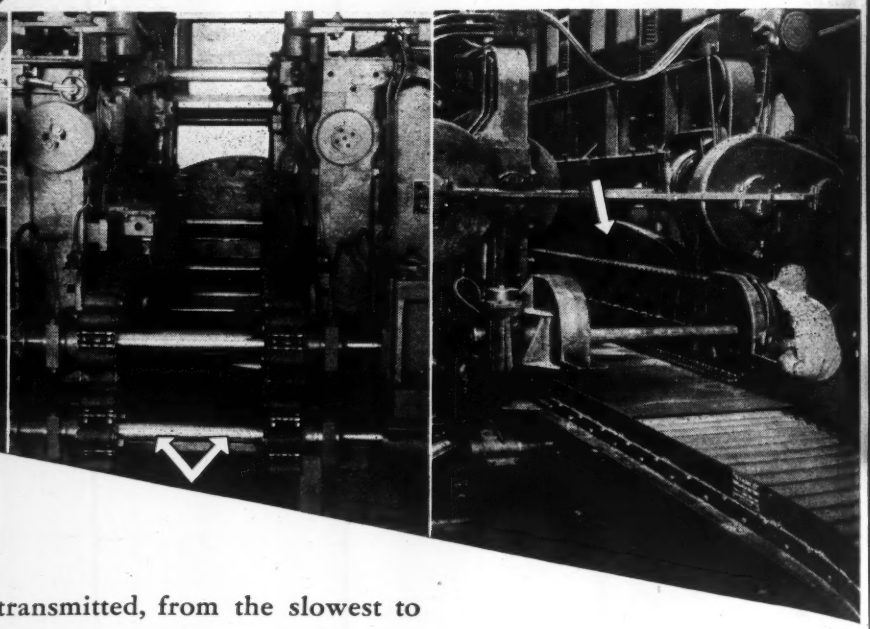
SPEEDIER OUTPUT

of Sheet Aluminum for Warplanes with Stamco Shears using DIAMOND CHAIN

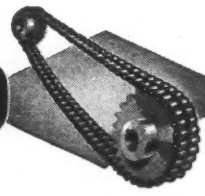


Faster shearing, slitting, corrugating and resquaring on Stamco equipment is an important factor in the rapidly increased output of sheet aluminum for all types of airplanes.

For motor, speed reducer and machine conveyor drives on this machinery, Stamco depends on Diamond Roller Chain. These drives match the metal-work machines themselves for great strength, accuracy and enduring stamina.



Wherever power is to be transmitted, from the slowest to the fastest practical speeds, Diamond Chains provide economical and satisfactory drives. Operating like a steel belt of roller bearings, they transmit 98-99% of the power from one shaft to another without creep or slip. The free rolling action, large area of contact and multiple oil films provide a smooth flow of power and eliminate destructive friction, vibration and wear.

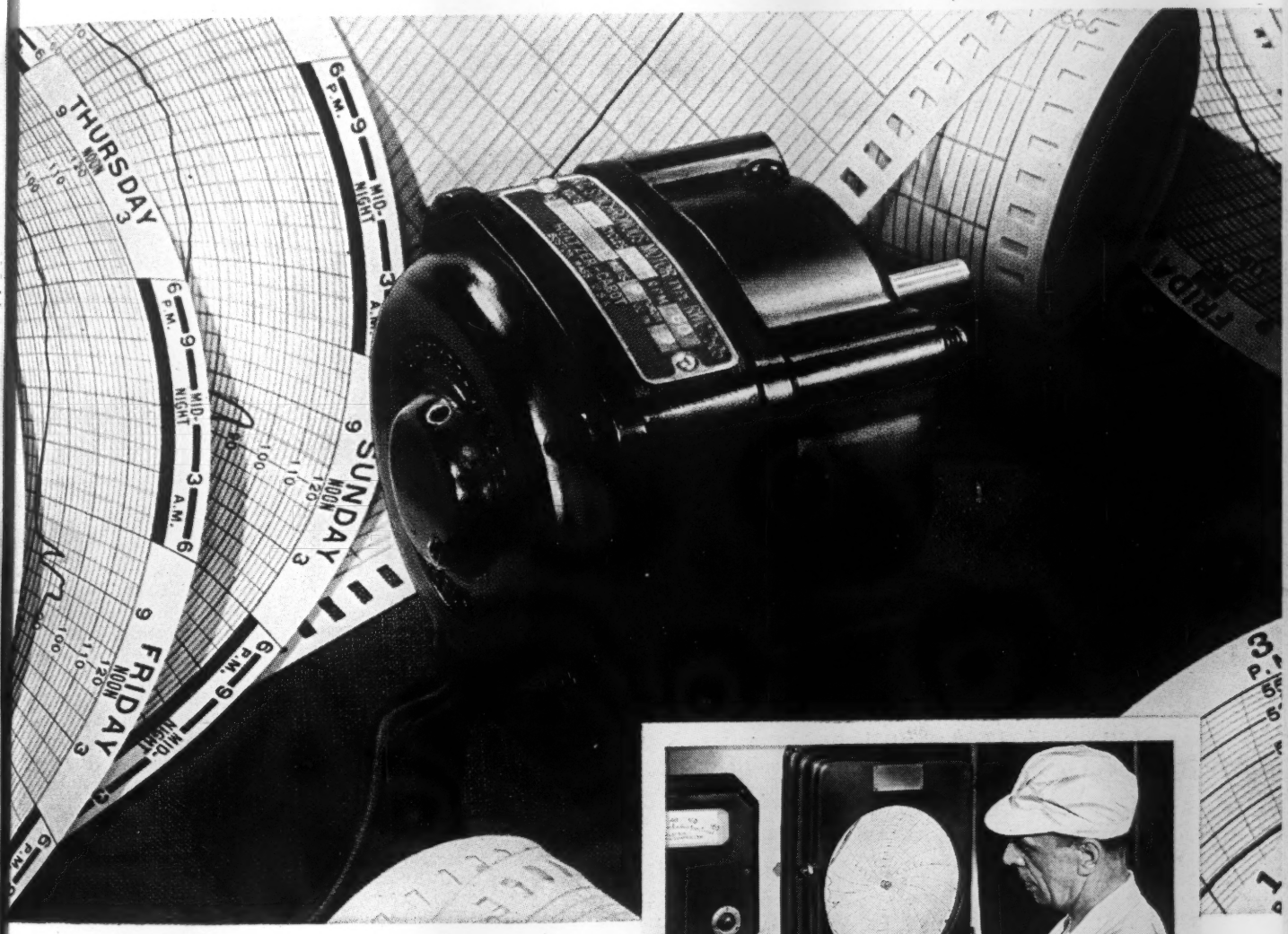


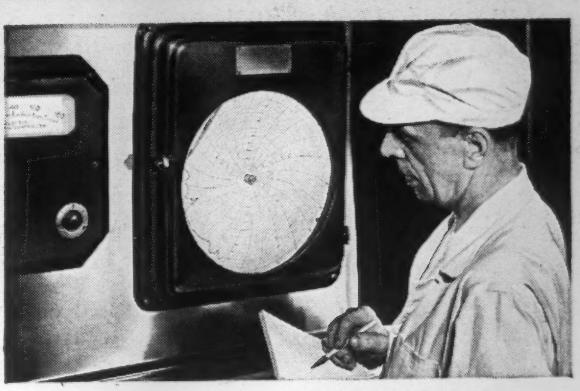
DIAMOND ROLLER CHAINS

It will pay you to be sure that Diamond Chain Drives are installed on your equipment. For further information or constructive recommendations write today to DIAMOND CHAIN & MFG. CO. 435 Kentucky Ave., Indianapolis 7, Ind.

Increased Power and Constant Speed

...YET FITS MOTOR SPACE AVAILABLE





Typical Recorder Powered with Holtzer-Cabot Motor

The requirements of a manufacturer of instruments called for a constant speed motor that had more power than a standard clock motor previously used, yet still fitted the original space allowed.

Holtzer-Cabot designed the special synchronous motor, illustrated above, which not only filled the performance and space requirements, but saved the manufacturer the cost of redesigning and retooling to take a larger motor, and also made it possible to service instruments in customers' plants which had the old type of clock motor.

The specialized business of Holtzer-Cabot is the designing and building of special fractional H. P. motors to meet special operating requirements.

Although, today, our entire facilities are devoted to manufacturing special motors for the armed forces, our motor development engineers will gladly discuss your post-war fractional H. P. motor requirements with you.

Special Motors Designed To Fit The Application

HOLTZER-CABOT

Division of First Industrial Corporation

Designers and Builders of Special Fractional HP Motors and Electrical Apparatus

125 AMORY STREET, BOSTON 19, MASSACHUSETTS • CHICAGO, ILLINOIS • NEW YORK, NEW YORK • PHILADELPHIA, PENNSYLVANIA

WHY YOU CAN'T SEE THE AIR

in the dining car . . .

Conditioning the air in modern railroad cars is a tough job. It calls for first rate engineering of heating, cooling, humidifying and particularly of air cleaning devices for use with fresh air intakes as well as with recirculated air.

Filters in these cars must be able to handle almost every conceivable type of dust, lint and dirt. A large percentage of these are made by Air-Maze, who offer filters of special design—one for fresh air and others for recirculated air.

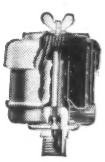
Preference for Air-Maze filters, not only in railroading but in dozens of other fields, is due to the fact that Air-Maze engineers co-operate closely with others who make control of air an exact science. Knowing the problems, and with the experience of nearly 20 years to draw upon, they have been able, time and time again, to solve the most difficult filtration problems.

Wherever clean air can remove a nuisance of health hazard or improve the quality of your product or service, consult Air-Maze *first.*

Air-Maze Filters *Fit* The Job

Typical ventilating panel filter.

Engine intake air filter. Oil bath type.



Oil bath breather filter for tanks, presses, etc.

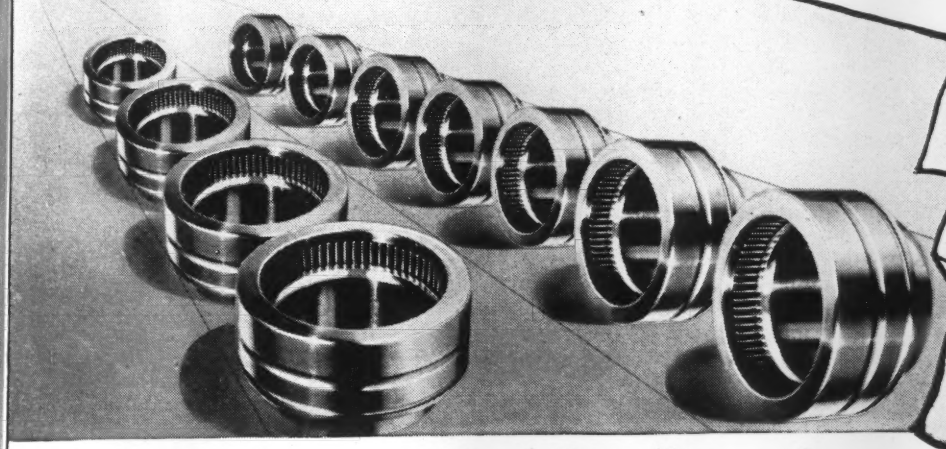
Oil-wetted type breather filter.

These are but a few of the hundreds of specialized filters developed by Air-Maze. Send for catalog AGC-144.

AIR-MAZE CORPORATION • *Engineers and Manufacturers* • **CLEVELAND 5, OHIO**

Representatives in Principal Cities • *In Canada:* Williams & Wilson, Ltd., Montreal, Quebec, Toronto, Windsor; Fleck Bros., Ltd., Vancouver, B.C.

PRECISION



CLUES to better Bearing Performance

- HIGH LOAD CAPACITY
- LIGHT WEIGHT
- SMALL SIZE
- UNIT CONSTRUCTION
- ECONOMY
- WEAR RESISTANCE
- CORRECT ALIGNMENT
- ALL TYPES— Full Range of Sizes
- PRECISION
- High Carbon Alloy Bearing Steel
- ELIMINATION OF FRICTION
- SILENCE

Another Clue to the Quality of

RBC NEEDLE BEARINGS

EXACT UNIFORMITY

Precise standards have been set up by R B C Engineers to secure strict uniformity in the manufacture of R B C Needle Bearings. These standards involve twenty-five years of bearing inventiveness as applied to design, application and production.

EVEN LOAD DISTRIBUTION

Each size group of R B C Bearings is as alike as two peas in a pod, not only in appearance, but more important in the vital load-carrying units that insure even load distribution. There can be no "lazy relations" in Aircraft, Machine Tool, Pump or Diesel Engine Bearings—each part must do its share of the work.

PUNCTILIOUS ACCURACY

R B C has many special machines and instruments manned by a large percentage of our personnel devoted to the job of inspection. This may be called "Ejecting lazy relations," but the result of this manifold police job is the R B C Bearing which is guilty only of punctilious accuracy.

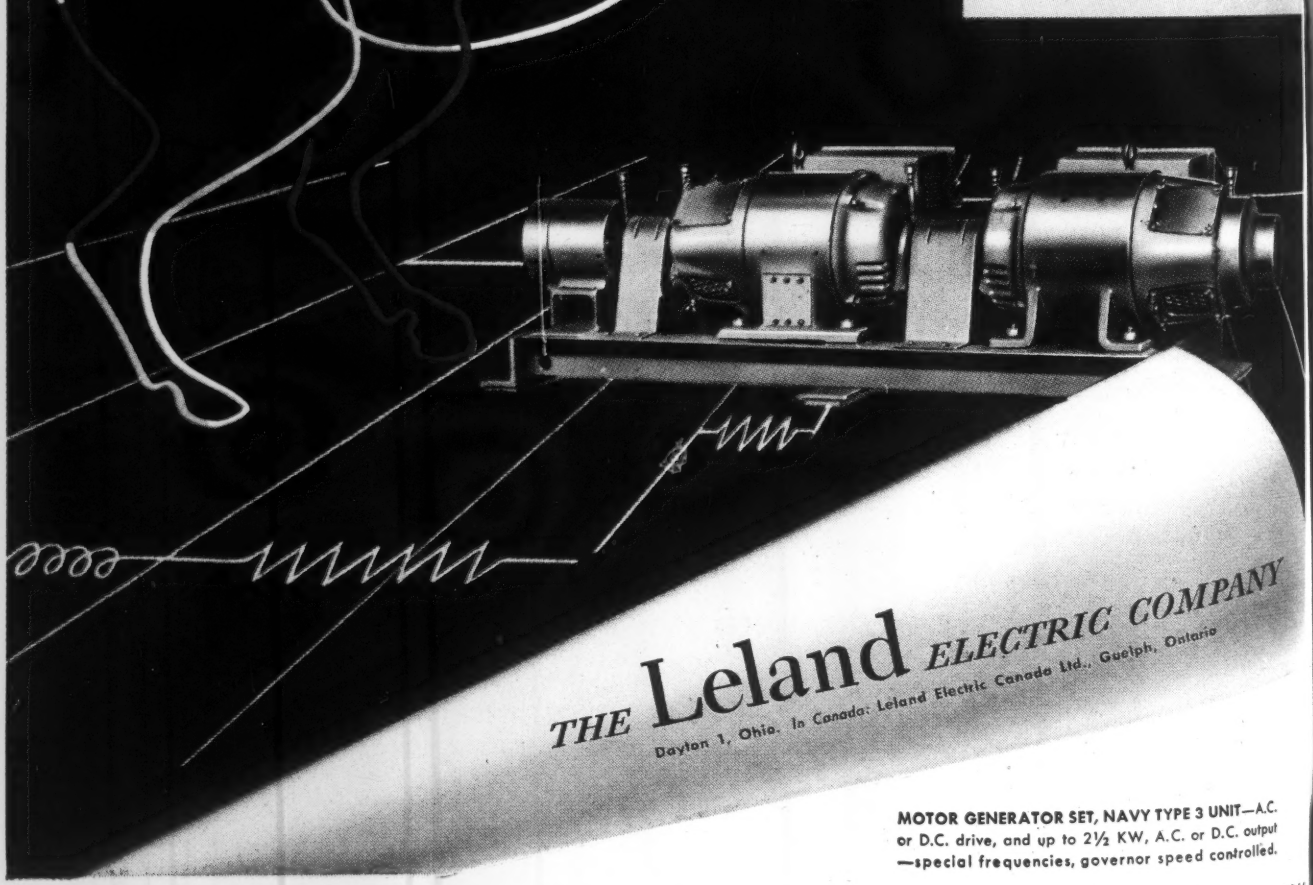
R B C's ENGINEERING STAFF WILL HELP YOU IN SELECTING THE RIGHT BEARING, AND IN FOLLOWING OUT THE CORRECT BEARING PROCEDURE. LET US KNOW YOUR PROBLEMS.

ROLLER BEARING CO. OF AMERICA
TRENTON, NEW JERSEY

CREATIVE ELECTRICAL ENGINEERING

Industry is entering an era of electronics, marked by the keenest competition in business history. The rich rewards will surely go to those who employ *Creative Electrical Engineering* to best advantage.

In this highly technical field, LELAND Electric has solved many difficult electrical problems with skill and ingenuity. This valuable experience may be the key to your post-war plan. We invite your inquiry.



THE Leland ELECTRIC COMPANY

Dayton 1, Ohio. In Canada: Leland Electric Canada Ltd., Guelph, Ontario

MOTOR GENERATOR SET, NAVY TYPE 3 UNIT—A.C. or D.C. drive, and up to 2½ KW, A.C. or D.C. output —special frequencies, governor speed controlled.

This Book May Help You Pick
THE FINISH FOR YOUR POSTWAR PRODUCTS

Polymerin Finish Dries Faster, Stays Beautiful Longer!

"The Facts on Polymerin" describes the two-way competitive advantages you can gain by finishing your postwar products with durable, speed-bake Polymerin.*

Polymerin is an organic baking enamel with unusual properties of durability and resistance . . . properties which may be varied to meet the individual requirements of such products as refrigerators, stoves, washing machines, bicycles, lamps, fluorescent reflectors, artificial tile, kitchen and under-sink cabinets, gasoline pumps, venetian blinds, vending machines and other appliances.

Polymerin stays beautiful longer! Impartial tests have shown that Polymerin is nine times harder to chip than ordinary enamels. And Polymerin—the original speed-bake finish—offers production advantages, too. For Polymerin's faster drying results in savings which can help you keep your finishing costs low!

Regular Polymerin is not available now, *but it is time now to discover how* Polymerin *can help you make and sell a better product after the war!* Use the coupon below to get your free copy of "The Facts on Polymerin", a 32-page booklet which presents clearly and factually the sales and production advantages of a Polymerin finish. This information-packed booklet is yours for the asking . . . send for a copy today!

**Reg. U. S. Pat. Off.*

POLYMERIN

The Original Speed-bake Finish

A PRODUCT OF AULT & WIBORG

DIVISION OF INTERCHEMICAL CORPORATION

G-2

Ault & Wiborg Division of Interchemical Corporation
Empire State Bldg., New York 1, N.Y.

Please send, without obligation, a free copy of "The Facts on Polymerin"—the book that shows how a Polymerin finish can increase sales and reduce finishing costs.

*Name*_____

*Company*_____

*Address*_____

FOR LONGER LIFE THRU GREATER STRENGTH

READY NOW! . . .

7 NEW MODELS IN MONOBLOC WITH THESE 7 EXTRA STRONG POINTS

1. *EASY TO INSTALL:* No suction piping required. Submerged unit column fits regular 2⅜" supporting clamp. Flanged unit supported by suction flange.

2. *ADJUSTABLE:* Applicable to sumps of various depths. May be turned to suit piping and conduit. Discharge openings in any one of three positions.

3. *ALWAYS PRIMED:* Casing and impeller always below liquid level . . . flanged unit especially suitable for shallow sumps.

4. *ADDED BEARING PROTECTION:* Extra grease seal keeps moisture or vapor away from bearings and motor.

5. *TOTALLY ENCLOSED MOTOR:* Completely protected against splash or drips.

6. *EXTRA LARGE SHAFT:* Maintains alignment of moving parts, assuring smooth operation. No guide bearing to wear out.

7. *LEAK PROOF:* No troublesome stuffing box or liquid seal.

Centrifugal Pumps | Rotary Pumps | Steam and Power Pumps | Vertical and Horizontal Compressors | Liquid Meters | Variable Speed Drives | Multi-V-Drives

36 DISTRICT OFFICES THROUGHOUT THE U. S.

NATION-WIDE SERVICE

. . . *another extra strong point*

Designers will welcome Monobloc Coolant and Circulating Pumps by Worthington – the biggest name in pumps – a name which above all means strength in machinery.

Yes – there's rugged durability in these new models, in their simple design, tough material and extra safeguards, 7 features in all which add up to *longer life*.

Designers will also welcome another feature which minimizes installation and service worries: no matter where you ship a Worthington pump, there's a Worthington man near your customer's installation.

Write for Bulletin W-321-B16. Standard Products Division, Worthington Pump and Machinery Corporation, Harrison, N. J., or telephone our nearest district office.

CP4-24

WORTHINGTON BEHIND THE NAME WORTHINGTON

WHERE WILL THE MONEY COME FROM TO MAKE HIS AMBITIONS COME TRUE?

YOU'LL find an important part of the answer in *rural America* . . . and the towns and small industry that are a part of the warp and woof of it!

There you'll find the fertile soil that will nourish the enormous purchasing power America must have to make our soldiers' ambitions come true.

All America . . . and American Industry in particular . . . has a stake in its continued well being.

Does this mean that sub-contracting so vital to the accomplishment of the miracle of American War Production is to be a factor of Post-War Production?

Will sub-contracting result not only in spreading the purchasing power but in providing a more efficient manufacturing procedure which in turn will make available more and better goods to more people?

As sub-contractors . . . as an organization located in one of America's smaller communities in the heart of the Middle West . . . to us, the answer is plain.

It is YES.

And while we of American Industry are now putting plans into action to make the miracle of post-war production come true . . . let us redouble our efforts in support of War Bond Sales whose essentiality for financing the war and providing an important base for post-war purchasing power is recognized by all of us.

★

This message is published in the interest of War Bond Sales and a prosperous post-war America of Free Enterprise by Burgess-Norton Mfg. Co., the services of whose Engineering staff, Metallurgical and Research Laboratories are available now to the manufacturers who will require piston pins, screw machine parts, heat treated and ground steel products, hydrogen copper brazing, non-precision ball bearings and related fabricated steel products.

Burgess Norton
MANUFACTURING COMPANY
40 years in GENEVA, ILLINOIS

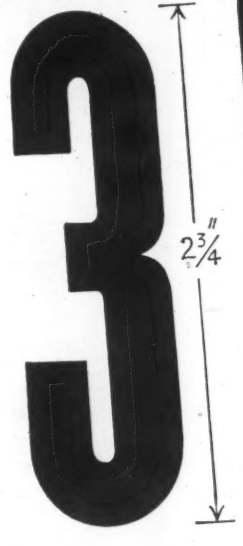
A Part is Never Made Right unless it is Satisfactory to Our Customers

365 BIG DATES FOR A DOLLAR!

EXTREME LEGIBILITY

Each numeral 2¾" high—that's the feature of this beautiful new six-color POST 1945 Calendar—overall size 17" x 25". Each date of the week is designed to be legible from any spot in the drafting room. The entire current month with ultimate and proximate months appear on each weekly page. The calendar is in full, brilliant color and includes a section devoted to significant drafting room data, covering charts on wire and sheet metal gages, screw threads, bolt heads, pipe and pipe fittings, gears, metric equivalent, and complete twelve-month calendar. Price $1.00. (Free if your request is attached to an order for POST merchandise.)

ACTUAL SIZE

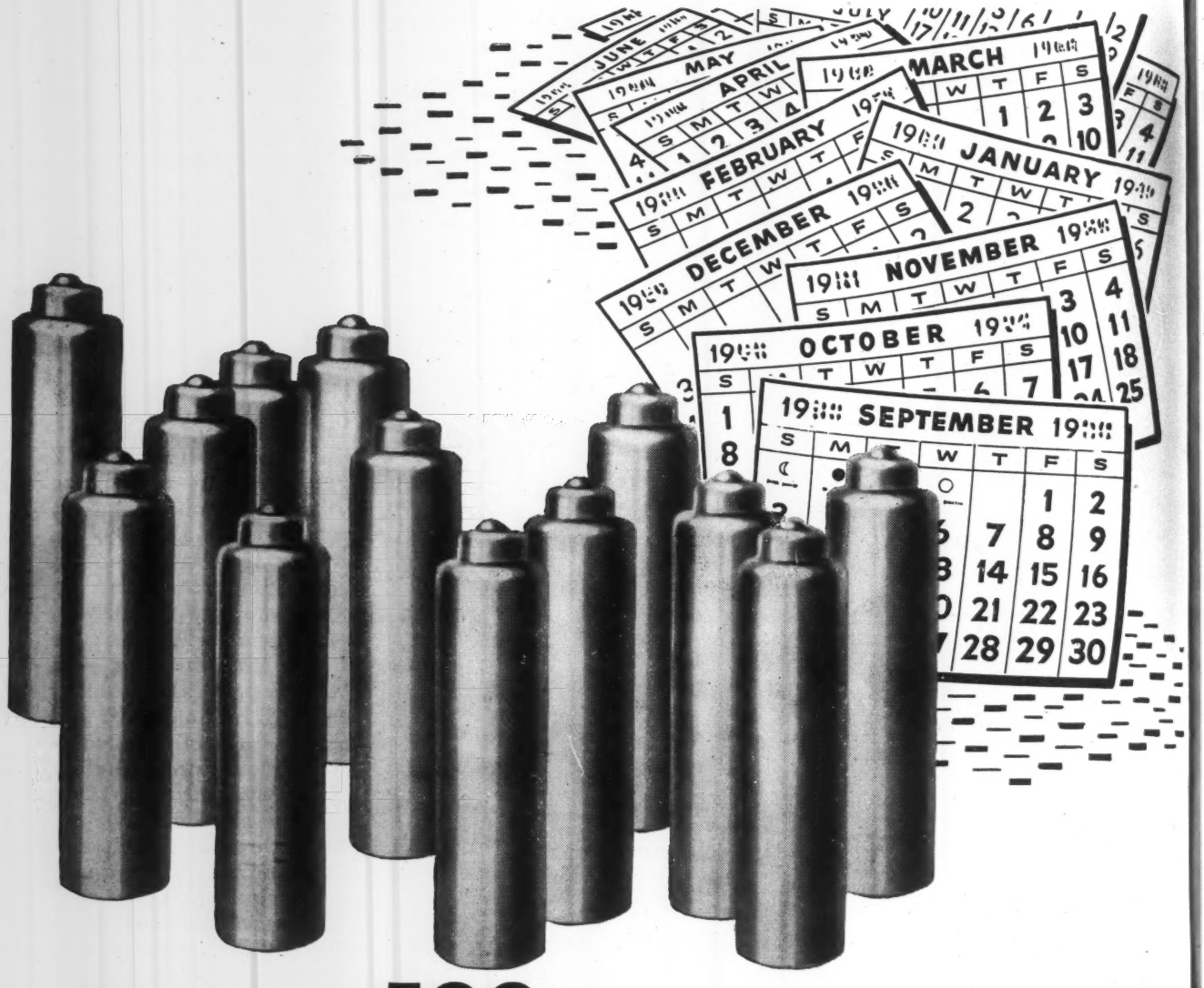


The FREDERICK POST COMPANY • Box 803 • Chicago 90, Illinois

Attached find $1.00 for a Giant 1945 Post Wall Calendar. (The calendar is FREE if you attach this coupon, filled in, to an order for POST merchandise)

NAME _____ COMPANY _____

ADDRESS _____ CITY & STATE _____



WHAT DO 500 MONTHS OF VOLUME PRODUCTION MEAN TO YOU?

Pressed Steel Tank Company's 500 months of volume production provide expert research, design and production experience. As a result, users are assured of ample strength to withstand costly damage . . . light weight with its important economy . . . and uniformity, which is one of the principal factors of continued customer preference.

Over 40 years of chemical and metallurgical research are at work to turn out better, lower cost parts for you. Hackney cold-drawn shapes and shells provide longer, lower cost service because of this long-time volume production experience.

From raw materials to the finished product, quality control is exercised, resulting in safety and economy for the user. Uniformity is assured in every manufacturing step.

At present the bulk of Pressed Steel Tank Company's facilities are given over to products intended for war purposes. However, as war restrictions are relaxed and there's more material available for civilian needs, every concern can benefit from Hackney's product development work and volume manufacturing.

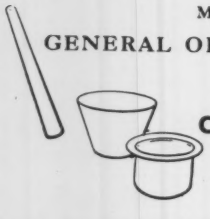
Pressed Steel Tank Company

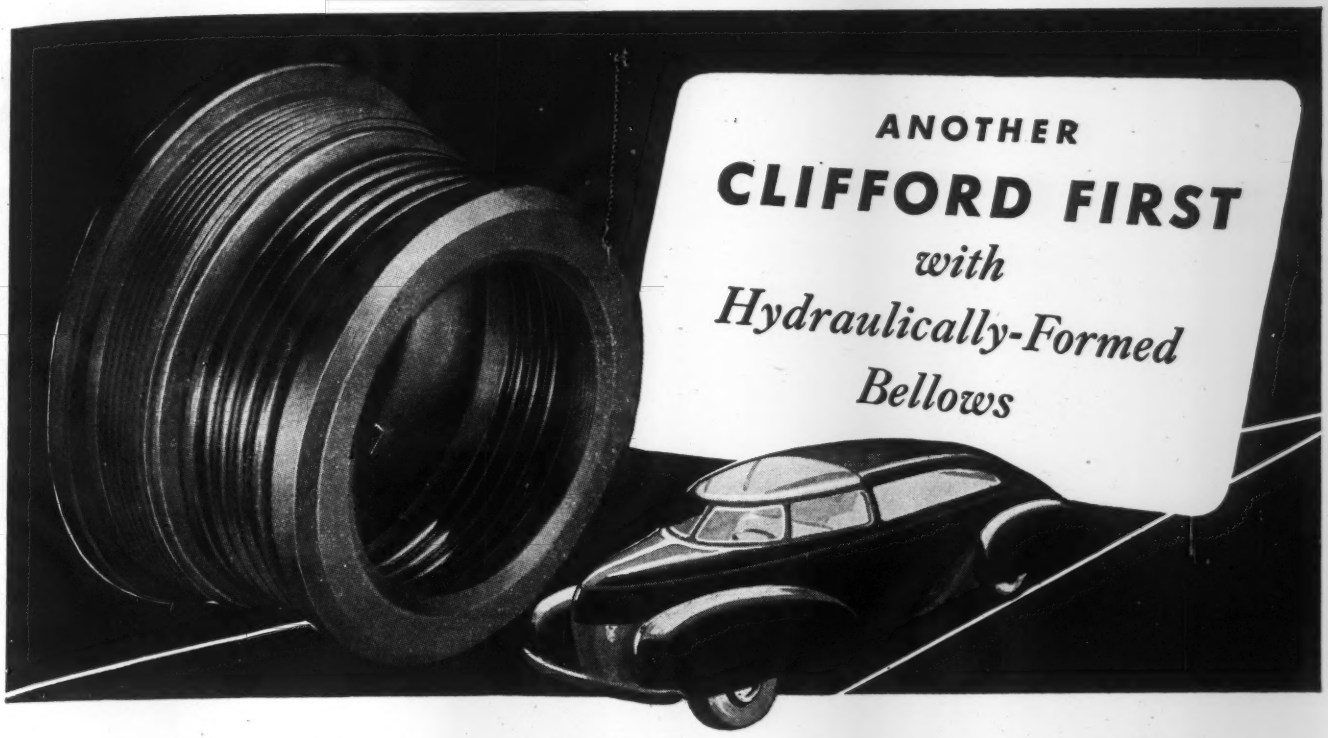
MANUFACTURERS OF HACKNEY PRODUCTS

GENERAL OFFICES AND FACTORY • 1435 SOUTH 66th STREET

Milwaukee 14, Wisconsin

CONTAINERS FOR GASES, LIQUIDS AND SOLIDS





Sealing OIL in and AIR out . . . at sub-zero to 500°F.

This shaft seal for an automobile fluid-drive coupling, representing one of the toughest bellows problems ever solved, stands as convincing evidence that Clifford is your best bet for all bellows problems, hard or easy.

This was the problem: — To produce a shaft seal that would not only seal the fluid in, under high temperature, heavy pressure and severe vibration conditions, but also prevent air from being sucked in when the motor was idling in very cold weather.

How Clifford solved it: — Others had tried to lick this problem and failed. To solve it, Clifford pioneered the process of silver-soldering thin-walled metal bellows to the end-fittings and flame-hardening the steel nose of the assembled unit without annealing the bellows.

The result: — This Clifford-engineered unit can withstand temperatures ranging from sub-zero to 500°F. and pressures up to 100 p.s.i. Solving tough bellows problems has equipped Clifford to engineer and manufacture in volume bellows seal assemblies for a wide range of temperatures and pressures.

Other problems solved by Clifford Bellows Assemblies involve controlling pressure or temperature — sealing rotary shafts or reciprocating valve stems — providing for expansion in pipe lines. Submit your problem. We may be able to help you to prepare now for peacetime volume production.

CLIFFORD MANUFACTURING CO.
BOSTON 27, MASS.

HYDRON Metal Bellows

CLIFFORD

First with the Facts on Hydraulically-formed Bellows

HYDRON

CLIFFORD Feather Weight

Feather-weight . . . the First All-Aluminum Oil Coolers and Coolant Radiators . . . Made with Hydron Tubing Brazed by Clifford's Patented Method.

CLIFFORD MANUFACTURING COMPANY
566 E. First Street, Boston 27, Mass.

Please send me a free copy of your 44-pg. Hydron Bellows Data Book. I am interested particularly in shaft seals for application to —

- ☐ Air compressors
- ☐ Fluid couplings
- ☐ Fuel oil pumps
- ☐ Gear boxes
- ☐ Paper machinery
- ☐ Refrigerant compressors
- ☐ Textile machinery
- ☐ Torque converters
- ☐ Washing machines
- ☐ Water pumps

Other applications.....

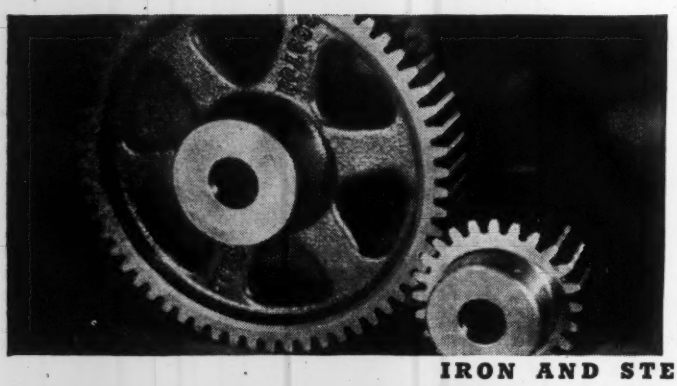
.....

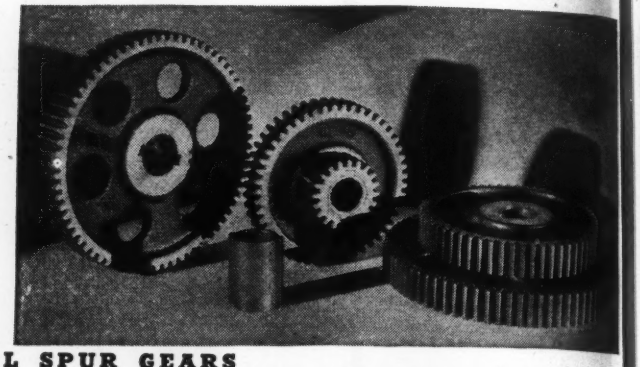
NAME.....

COMPANY.....

ADDRESS.....

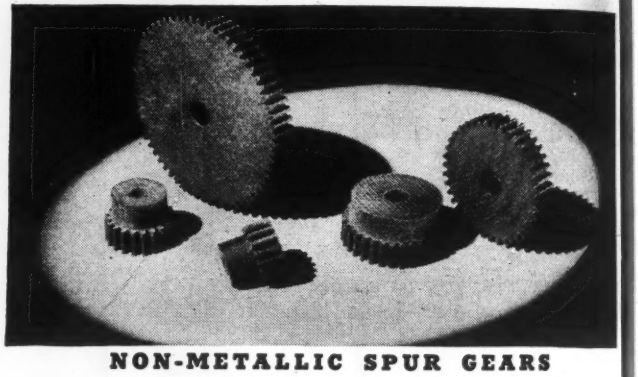
SPUR GEARS





IRON AND STEEL SPUR GEARS

BRASS SPUR GEARS



NON-METALLIC SPUR GEARS

Many sizes of Boston Gear Standard spur gears are IN STOCK READY FOR YOUR IMMEDIATE USE. Boston Gear Standard sizes comprise the following: iron and steel spur gears in pitch diameters from ½" to 40", brass spur gears in pitch diameters from 5/24" to 6", and non-metallic spur gears in pitch diameters from 15/16" to 6⅔". Representative stocks of these spur gears are carried by the following authorized distributors and direct company branches, any of whom will be pleased to give you complete specifications and prices of these products.

AKRON, OHIO
Manufacturers Rubber & Supply Company
ALBANY, NEW YORK
Sager-Spuck Supply Co., Inc.
ALLENTOWN, PENNSYLVANIA
Wm. H. Taylor & Co., Inc.
ATLANTA, GEORGIA
J. M. Tull Metal & Supply Co.
BALTIMORE, MARYLAND
Carey Machinery & Supply Co.
BOSTON, MASSACHUSETTS
Boston Gear Works, Inc.
Chandler & Farquhar Co., Inc.
BRIDGEPORT, CONNECTICUT
Hawley Hardware Co.
BROOKLYN, NEW YORK
H. L. Dickie
BUFFALO, NEW YORK
Root, Neal & Co.
BURLINGTON, NORTH CAROLINA
Kester Machinery Co.
CANTON, OHIO
Manufacturers Rubber & Supply Company
CHARLOTTE, NORTH CAROLINA
Mathews-Morse Sales Co.
CHICAGO, ILLINOIS
Berry Bearing Co.
Boston Gear Works, Inc.
Chicago Pulley & Shafting Co.
Power Transmission Equipment Company
CINCINNATI, OHIO
Queen City Supply Co.
CLEVELAND, OHIO
Boston Gear Works, Inc.
Mau-Sherwood Supply Co.

DALLAS, TEXAS
Geo. J. Fix Co.
DAVENPORT, IOWA
Standard Bearings Co.
DAYTON, OHIO
Klinger-Dills Co.
DENVER, COLORADO
Denver Equipment Co.
Western Belting & Packing Co.
DES MOINES, IOWA
Standard Bearings Co.
DETROIT, MICHIGAN
Chas. A. Strelinger Co.
EVANSVILLE, INDIANA
Bearings Service Co., Inc.
HARTFORD, CONNECTICUT
Silliter-Holden, Inc.
HIGH POINT, NORTH CAROLINA
Kester Machinery Co.
INDIANAPOLIS, INDIANA
Indianapolis Belting & Supply Co.
Vonnegut Hardware Co.
JACKSONVILLE, FLORIDA
S. B. Hubbard Co.
KANSAS CITY, MISSOURI
Ellfeldt Machinery & Supply Co.
LOS ANGELES, CALIFORNIA
Andrews Hardware & Metal Co.
Garrett Supply Co.
LOUISVILLE, KENTUCKY
Industrial Equipment Co.
MEMPHIS, TENNESSEE
Lewis Supply Co.
MIAMI, FLORIDA
Miami Parts & Spring Co.
MILWAUKEE, WISCONSIN
Western Iron Stores Co.

MINNEAPOLIS, MINNESOTA
R. C. Duncan Co.
NASHVILLE, TENNESSEE
Keith, Simmons Co., Inc.
NEWARK, NEW JERSEY
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NEW BRITAIN, CONNECTICUT
Smith & Klebes, Inc.
NEW HAVEN, CONNECTICUT
C. S. Mersick & Co.
NEW ORLEANS, LOUISIANA
R. J. Tricon Co.
NEW YORK, NEW YORK
Morris Abrams, Inc.
L. C. Biglow & Co., Inc.
Boston Gear Works, Inc.
Bronx Hardware & Supply Co.
NORTH QUINCY, MASS.
Boston Gear Works, Inc.
OAKLAND, CALIFORNIA
C. W. Marwedel
PEORIA, ILLINOIS
Illinois Bearing Co.
PHILADELPHIA, PENNSYLVANIA
Boston Gear Works, Inc.
Maddock & Co.
PITTSBURGH, PENNSYLVANIA
Somers, Fitler & Todd Co.
PORTLAND, OREGON
Woodbury & Co.
PROVIDENCE, RHODE ISLAND
Machine Parts Corp.
RICHMOND, VIRGINIA
Apex Machine Mfg. Co.
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Kester Machinery Co.
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W. M. Steele Co.

★ ★ ★

CANADA, MONTREAL
Renold Coventry, Ltd.
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CANADA, VANCOUVER
Renold Coventry, Ltd.

BOSTON GEARS

They mold them BIGGER and BIGGER with LUMARITH*

A Celanese Plastic*

Injection molded plastic pieces of this size were undreamed of a few years ago. But progress in injection machines, dies, molding materials and techniques has been so rapid that no one can predict the limit.

Much credit for these advances must go to the molder. But working hand in hand with this industry, the Celanese development of Lumarith* molding materials has been an important factor. Because of Lumarith's moldability and free-flowing characteristics, together with its high impact strength and toughness, these plastics have always been in the vanguard of the steady march to ever-larger molded pieces.

If you have in mind large plastic parts, from refrigerator sections to housings of any type, you will find our Technical Service Department a good place to start the practical discussion. We welcome your inquiry. Celanese Celluloid Corporation, a *division of Celanese Corporation of America*, 180 Madison Avenue, New York 16, N. Y.

*Reg. U. S. Pat. Off.

This is the ventilator tube for the great P47 Thunderbolt. Both halves molded in one shot by The Pyro Plastics Co., Westfield, N. J.

ENDLESSLY the Improvement goes on...

● Since 1913, in the Formica Laboratories, a considerable force of competent research men has been busy every day seeking new ways to improve Formica and its usefulness to industry.

They have worked out a long line of improvements which have been additions to the art. During these war years they have been exceptionally busy, and productive.

Among the important recent developments have been glass cloth and glass mat grades for high mechanical strength, and improved insulation of high freqency currents; Pregwood for airplane propeller blades and other mechanical uses; alkali resistant grades for chemical processes, better laminated translucent sheet, sturdier and more decorative Formica finishes.

There are others which will soon be unveiled. All the knowledge of this laboratory is at your disposal when you have a problem in the use of laminated plastics to solve. Ask for it

"The Formica Story" is a moving picture in color showing the qualities of Formica, how it is made, how it is used. Available for meetings of business groups.

ARMY E NAVY

FORMICA

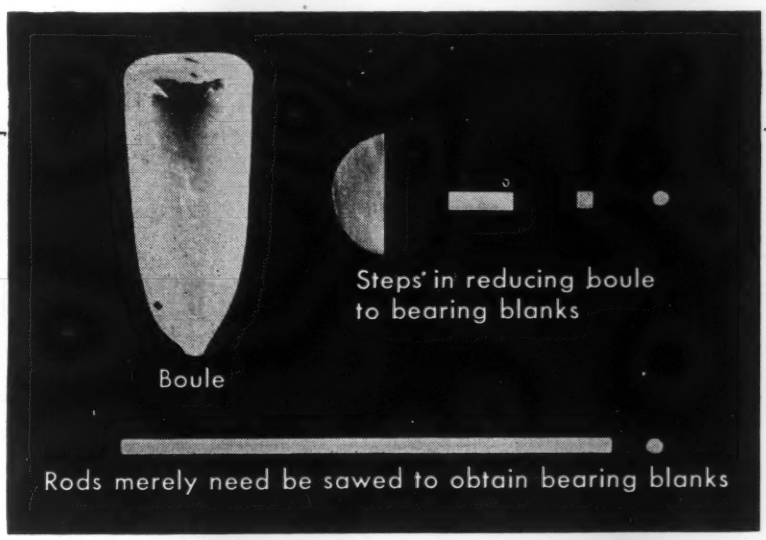
THE FORMICA INSULATION COMPANY, 4648 Spring Grove Avenue, Cincinnati 32, Ohio

Linde

SAPPHIRE AND RUBY

(Synthetic Corundum)

Now Available in any Quantity, for any Purpose, without Priority



The advantage of the new rod form over the boule is illustrated here.

LINDE Sapphire and Ruby have been removed from W.P.B. allocation and can now be obtained without priority in any quantity for any use.

What They Are

LINDE Sapphire, water-clear corundum, and Ruby, red corundum, are crystalline forms of alumina. These materials offer a unique combination of properties to machine and product designers in many industries. They are single crystals second only to the diamond in mineral hardness and can be given a surface that is perfectly smooth. They are invaluable in bearings and many other parts where there is wear.

What Their Properties Are

Melting Point	2,050 deg. C.
Hardness, Mohs' Mineral Scale	9.
Tensile Strength	65,000 lb. per sq. in.
Chemical Resistance	Excellent
Thermal Conductivity	Low
Electrical Conductivity	Low

Where They Are Used

LINDE Sapphire and Ruby are now being used for such applications as: bearings, thread guides, extrusion dies, gages, knife edges, spray nozzles, oil-burner nozzles, wire guide dies, burnishing tools, pressure vessel windows, and electrical insulators.

How They Are Supplied

LINDE Sapphire and Ruby are supplied in half boules, weighing up to 150 carats and as rods of .070 in. to .125 in. diameter. More complete information will be sent on request.

BUY UNITED STATES WAR BONDS AND STAMPS

MARITIME "M" AWARD FOR OUTSTANDING PRODUCTION ACHIEVEMENT

THE LINDE AIR PRODUCTS COMPANY

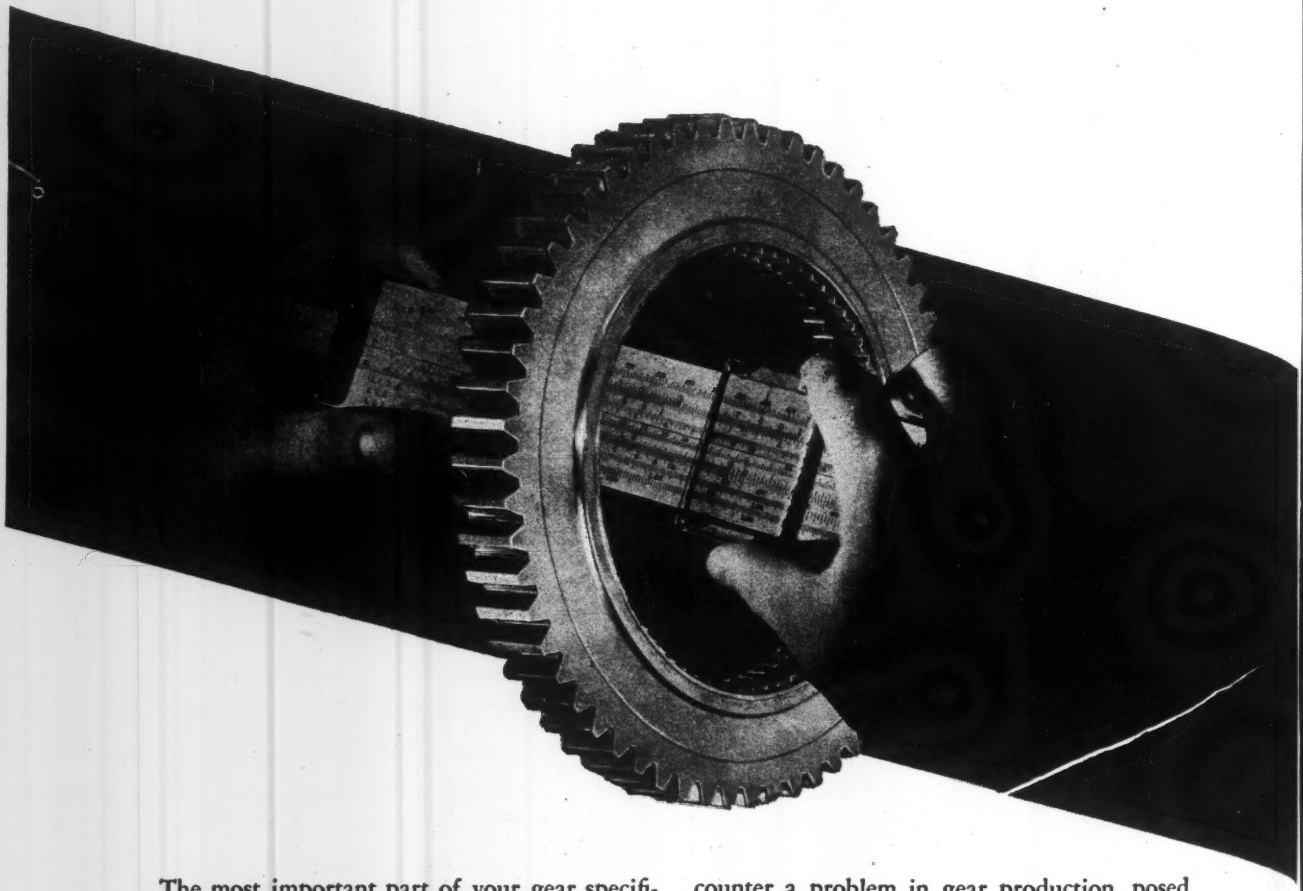
Unit of Union Carbide and Carbon Corporation

30 E. 42nd Street UCC New York 17, N. Y.

The word "Linde" is a trade-mark of The Linde Air Products Company.

Perkins provides

WHAT YOUR CALCULATIONS CAN'T COVER



The most important part of your gear specifications is that which no specification could possibly contain. Namely, the ability of the gear manufacturer to live up to it.

Here at Perkins, we do not claim to have a monopoly on the country's gear engineering brains. In fact—and with a friendly nod to our competitors—we freely concede the existence of other good gear manufacturers. With an exceptionally vast amount of experience-data to draw upon, however, we have yet to encounter a problem in gear production, posed by a customer's specifications, which we have not solved successfully, provided it came within the range of our production facilities. Better still, it has frequently been possible for us—through close cooperation with customers' technical staffs—to improve power transmission over and above the point which the original gear specification was calculated to provide. Perkins gear engineering know-how is the answer. Consult with us now.

PERKINS PRECISION, CUSTOM-CUT GEARS

PERKINS MAKES:

Helical Gears *Bevel Gears* *Ratchets*
Worm Gears *Spiral Gears* *Spur Gears*
Ground Thread Worms

PERKINS MACHINE & GEAR COMPANY, SPRINGFIELD 2, MASS.

Your Machine is Your Idea Brought to Life

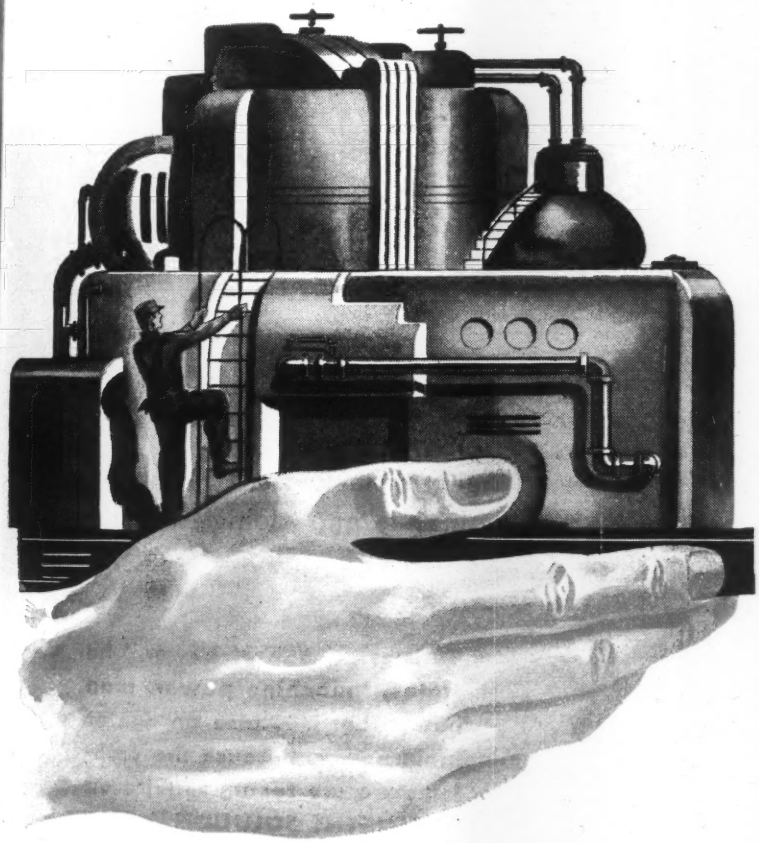
Protect it from Costly Human Error!

• There she is—*your new machine!* Fresh out of your "think tank." Her nose may be shiny, but she's beautiful... ready and able to do a certain job better than anything in her class. And she's yours, *all* yours!

Now that you're sending her out in the world, she's going to be at the mercy of human beings. And just because people are *human*, they make mistakes. Costly mistakes that can cut down the full productiveness of your machine.

But when it comes to lubrication, there is a way to protect your "working girl" and insure her for life against human error. Design-in any one of the four new Alemite Centralized Lubrication Systems—the Alemite Progressive, Alemite Dual Progressive, Alemite Dual Manifold and Alemite LubroMeter.

These Systems were created by Alemite for the single purpose of eliminating "human error" in lubrication. They handle both grease and oil. And they're so adaptable you can build them into almost any type of machine, large or small, singly or in batteries.



ALEMITE CENTRALIZED LUBRICATION SYSTEMS

Give Your Machines All These Advantages—Plus Protection!

★ They assure positive lubrication for all bearings.

★ They provide measured delivery of lubricants to each bearing; prevent over-lubrication and under-lubrication. The systems signal when the lubrication job is completed.

★ They permit lubrication while machines are in operation. No time-outs or shut-downs for lubrication. This adds "M. P. T." (More Productive Time) to your machines.

★ They eliminate the need for costly field service. Machines perform better because they are properly lubricated.

★ They add potent sales points to your machines, enhance your own reputation as a designer. Alemite Systems pay for themselves quickly through greater production, lower labor and lubricant expense, longer life of machines.

Here's How Centralized Lubrication Increases Production . . . Saves Time, Money and Machines!

One battery of machines had to be shut down 17 minutes each shift for lubrication. An Alemite Centralized System did the job better in 3 minutes—added 5 hours more productive time to each machine each week! That's 260 *extra* working hours per machine every year!

To lubricate this large machine—65 feet high, 100 feet long—the oiler had to cross a catwalk, lean over and reach down to remotely located bearings. The job was time-consuming and dangerous. An Alemite Centralized System was installed. Now all 59 bearings are lubricated safely, quickly and easily from 3 locations, in minutes! Hazard is removed... lubrication is done better and faster... productive time is increased!

Have a Demonstration of the 4 New Alemite Systems . . . Right at Your Desk!

Without obligation, have an Alemite Lubrication Specialist call and demonstrate Centralized Lubrication with four transparent working models. They're mighty interesting. You can study them at close range—actually work them yourself at your desk! If you like, the Alemite Specialist will gladly give you any technical help or information you may want regarding the adaptation of Alemite Centralized Lubrication Systems to your old or new machines. Drop a note on your letterhead to Alemite, 1804 Diversey Parkway, Chicago 14, Illinois.

Another Product of STEWART WARNER

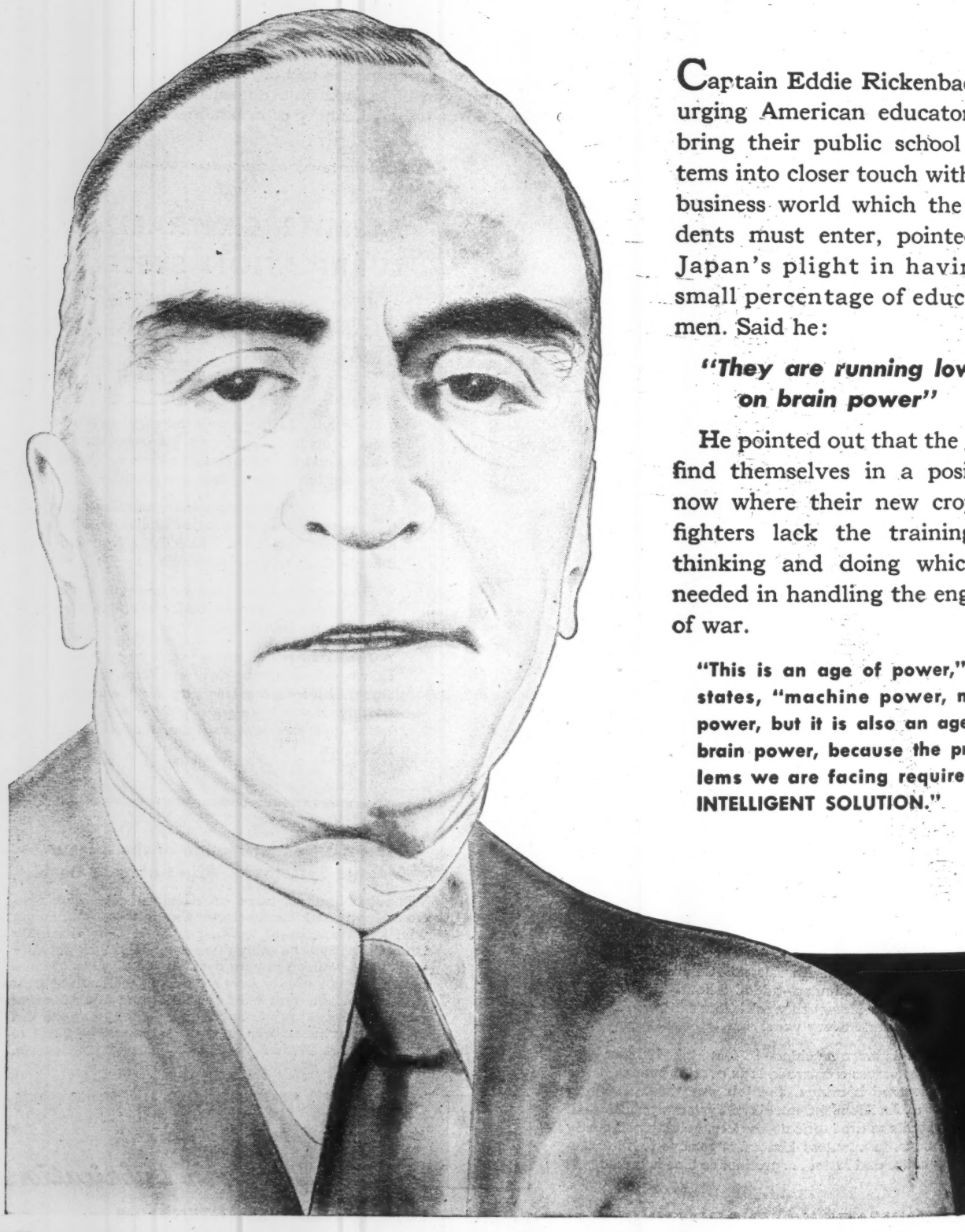
ALEMITE

First in Modern Lubrication

CONSULTATION • ENGINEERING • EQUIPMENT • LUBRICANTS • MAINTENANCE

then he said to himself

"They're Short on Brains"



Captain Eddie Rickenbacker, urging American educators to bring their public school systems into closer touch with the business world which the students must enter, pointed to Japan's plight in having a small percentage of educated men. Said he:

"They are running low on brain power"

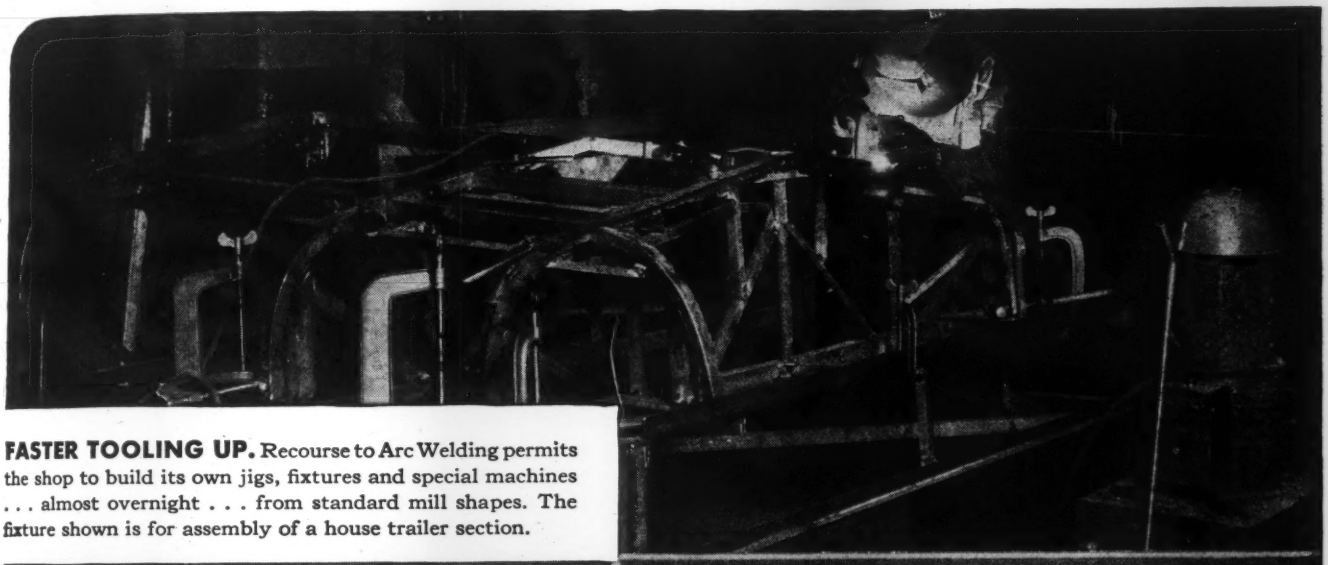
He pointed out that the Japs find themselves in a position now where their new crop of fighters lack the training in thinking and doing which is needed in handling the engines of war.

"This is an age of power," he states, "machine power, man power, but it is also an age of brain power, because the problems we are facing require an INTELLIGENT SOLUTION."

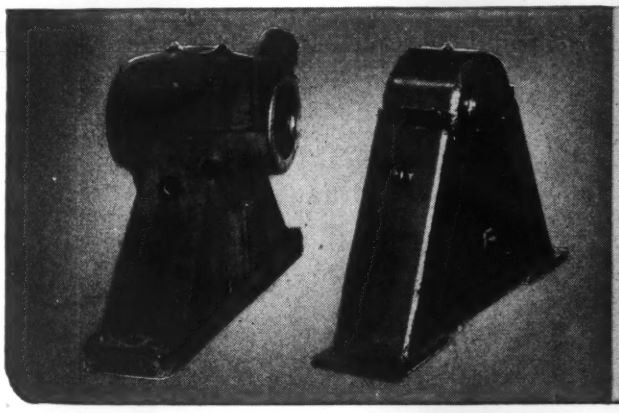
"INTELLIGENT SOLUTION," *he says*

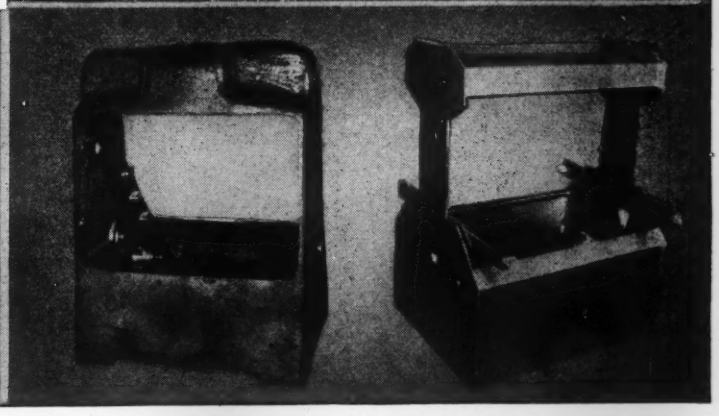
LOOK, CAPTAIN, how recourse to Arc Welding affords intelligent solution to reconversion problems:

RECONVERSION SIMPLIFIED



FASTER TOOLING UP. Recourse to Arc Welding permits the shop to build its own jigs, fixtures and special machines . . . almost overnight . . . from standard mill shapes. The fixture shown is for assembly of a house trailer section.





LOWER COSTS! Recourse to Arc Welding allows greater freedom of design of the product...using any combinations of shapes or types of materials. NO patterns to make. Design and production can be constantly improved at minimum cost. Changeover of this bearing pedestal to welded steel cut cost from $138.70 to $71.35; cut weight from 395 lbs. to 280 lbs.

MORE SALEABLE PRODUCTS! Recourse to Arc Welding makes products stronger, lighter, more rigid and of improved appearance. Changeover of this frame of a bread-slicing machine saved 60 sq. in. of floor space, reduced weight 30%, increased accuracy of bearing alignment, cut costs 30%.

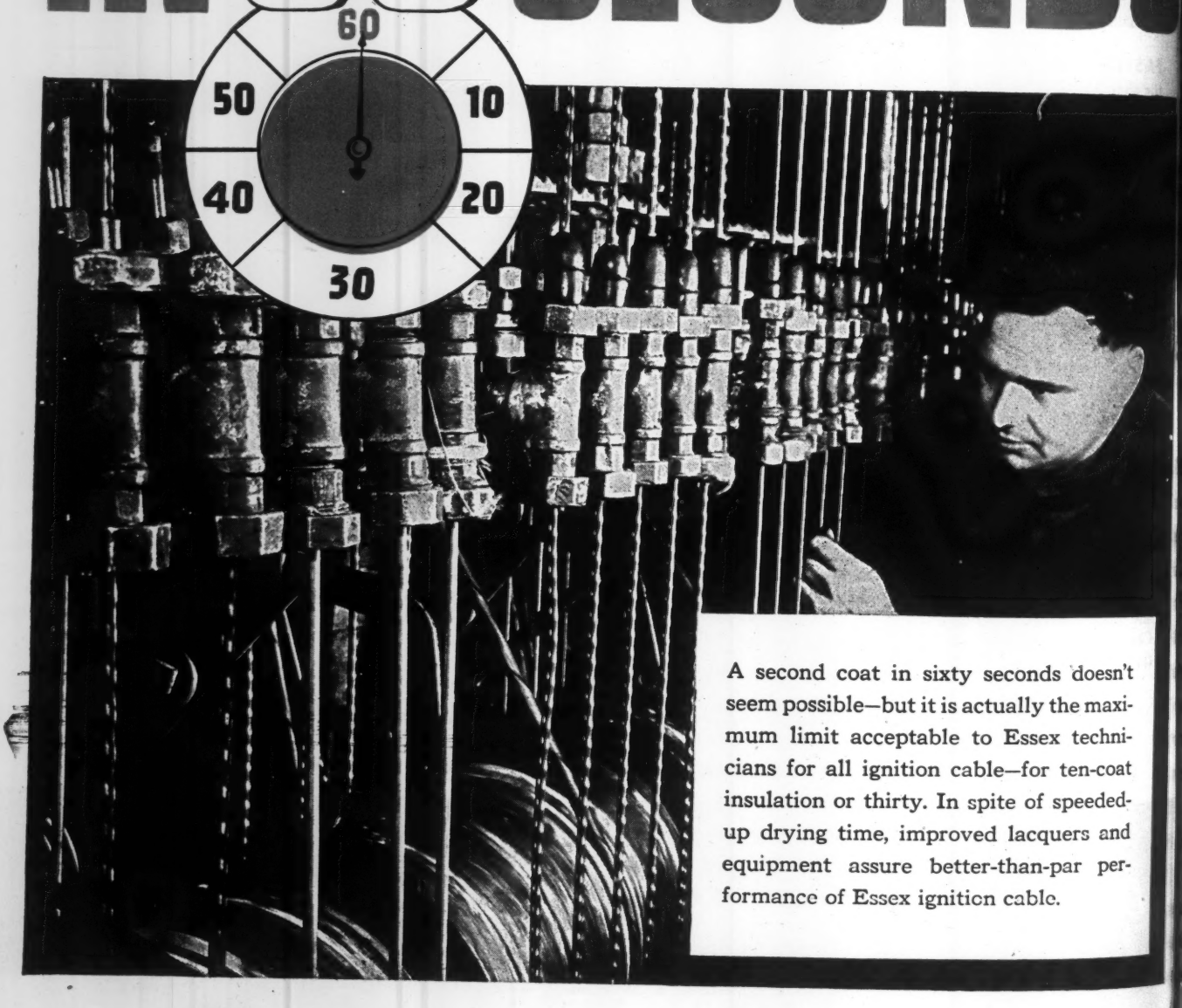
The Lincoln Welding Engineer nearby will help you solve reconversion problems with Arc Welding.

THE LINCOLN ELECTRIC COMPANY • CLEVELAND 1, OHIO

America's greatest natural **recourse**

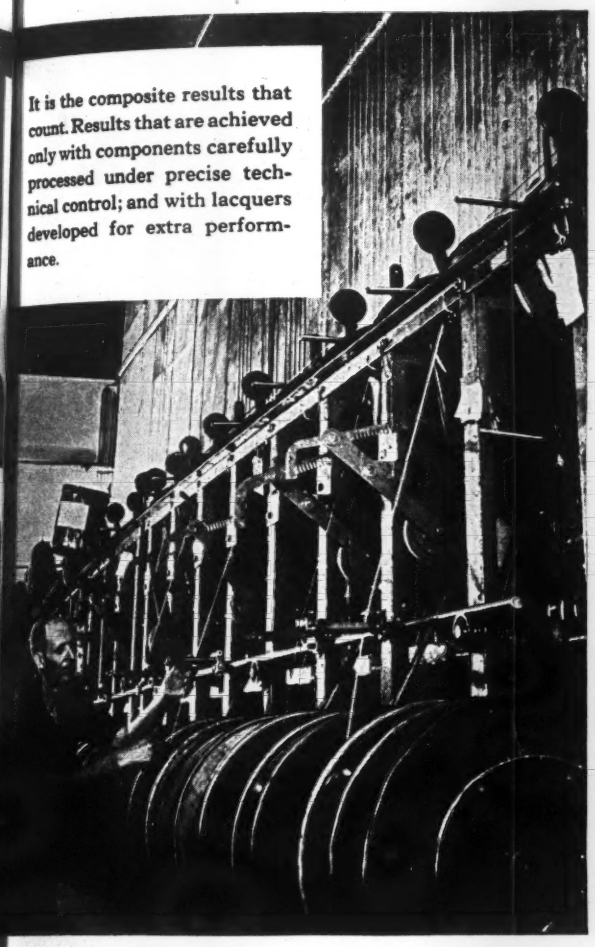
ARC WELDING

SECOND COAT IN 60 SECONDS

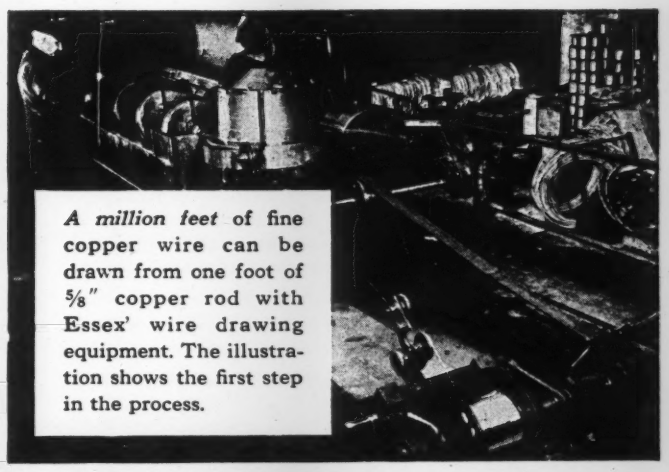


A second coat in sixty seconds doesn't seem possible—but it is actually the maximum limit acceptable to Essex technicians for all ignition cable—for ten-coat insulation or thirty. In spite of speeded-up drying time, improved lacquers and equipment assure better-than-par performance of Essex ignition cable.

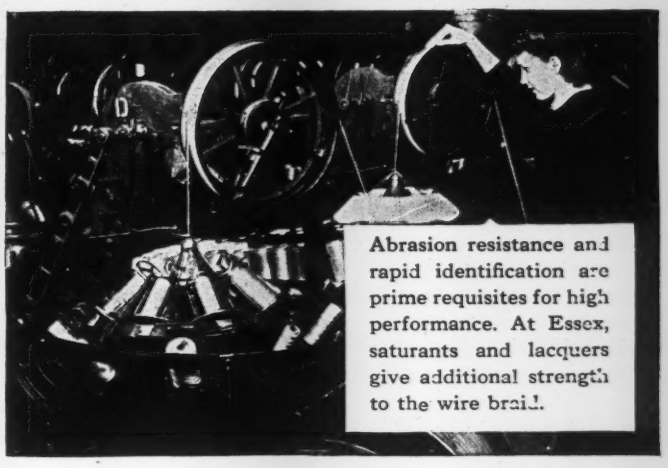
SHERWIN-WILLIAMS



It is the composite results that count. Results that are achieved only with components carefully processed under precise technical control; and with lacquers developed for extra performance.



A million feet of fine copper wire can be drawn from one foot of 5/8" copper rod with Essex' wire drawing equipment. The illustration shows the first step in the process.



Abrasion resistance and rapid identification are prime requisites for high performance. At Essex, saturants and lacquers give additional strength to the wire braid.

ssex Wire Corp. and SHERWIN-WILLIAMS speed up lacquer-coating of wire

litary demands have been many times greater l far more exacting than peace-time requirents of wire and cable. The government put in h orders for miles and miles of insulated copper e. RUSH! MORE WIRE! BETTER WIRE! ich of the wiring was to be subjected to rough ndling. New flame-proof types of coating had to developed. That meant various thicknesses of ulation—as many as thirty coats of lacquer—deding upon the job to be done.

Multiple coats meant speed and MORE SPEED the drying time between coats.

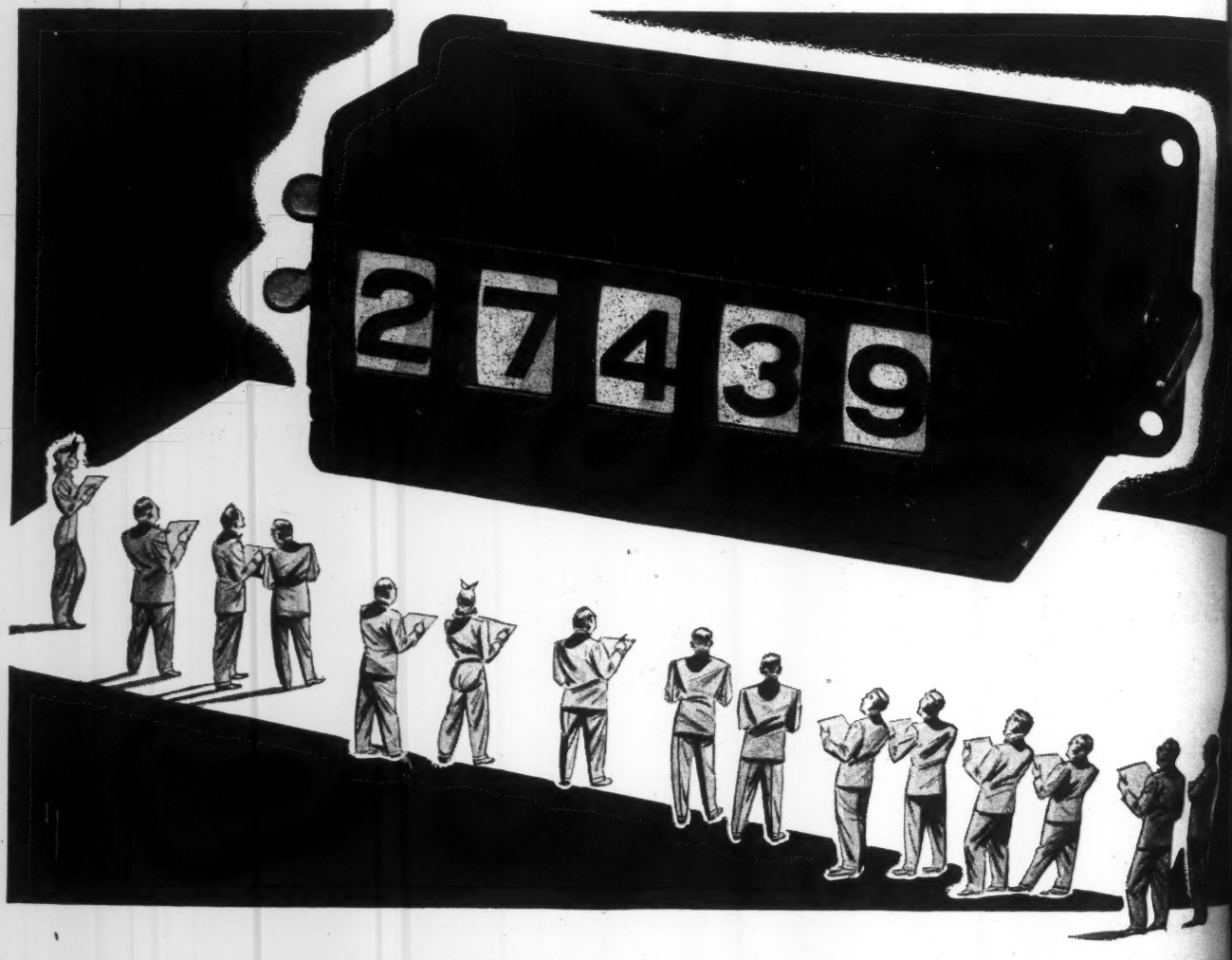
Sherwin-Williams gave Essex invaluable assisnce by quickly supplying new, improved or cometely revamped lacquers that cut drying time tween coats to approximately one minute. These improvements enabled Essex Wire to supply our armed forces with cables of highest performance—without increasing production costs!

Just another instance when Sherwin-Williams was able—and willing—to pass on the accumulated experience of its staff of finishing experts. The Industrial Finishing Division of Sherwin-Williams was founded to help industry solve its finishing problems; and its fund of know-how is at your disposal. The Sherwin - Williams Company, Cleveland 1, Ohio.

INDUSTRIAL FINISHES

Here's what Veeder-Root "COUNTROL"

CAN MEAN TO USERS OF YOUR MACHINES



It means that you give them an added utility-feature which helps them to get *consistently* out of your machines all the performance you build in.

For Veeder-Root "*Count*rol" is based on the performance-figures which endlessly turn up in the windows of Veeder-Root Counting Devices . . . showing at a glance exactly where production stands at any given moment, in terms of strokes, turns, lengths, volumes, trips, pieces, or other units. And by checking these figures at frequent intervals, your customers can tell whether production is up to or ahead of schedule . . . when fresh stock should be fed . . . when maintenance is coming due.

Veeder-Root Counting Devices are compactly designed, with simple drive-connections, in scores of types for mechanical or electrical operation. And they can be readily designed into any product, as integral parts. Let a Veeder-Root engineer show you exactly what your product can gain in usefulness to its users, by the simple addition of "*Count*rol."

VEEDER-ROOT INCORPORATED

HARTFORD 2, CONNECTICUT

The Counting House of Industry

In Canada: **Veeder-Root of Canada, Ltd., Montreal** ***In England:*** **Veeder-Root Ltd. (New address on request)**

Sgt. Spring, M.E., E.E., MET.E., CH.E., etc.

WE'VE GOT HIM COVERED

From the Hunter Data Book have sprouted many ideas for spring-operated devices that are doing their bit to finish off the Axis. This handy fact-packed book is full of information you need at your desk or drawing board. For a free copy, send your signature on your business letterhead. It will be mailed promptly.

THERE was a time, very likely within your memory—when a spring was simply a curlicue of wire. You made it. If it didn't work, you gave it another twist and tried again. This cut-and-try approach was certainly not design—and hardly economical manufacture. But it had its day . . . and that day is over.

Now, to fit a spring precisely for the job it must do in your product . . . to make it an ambassador of the quality and performance your customers expect from you, requires all the scientific knowledge a spring manufacturer can bring to bear.

The most naive-looking spring will often surrender only to the combined efforts of calculus, metallurgy and statistical control of quality. But in 99-44/100 percent of the problems, science wins out where rule-of-thumb would flop. The war has proved the case for scientific spring making. Future applications will rest on that proof.

THE BARREL SPRING—*The barrel spring is a fundamental spring form, designed to resist, or store up until wanted, a compressive force, and to compact into the minimum solid height. One of many for-instance applications for barrel springs is shown in the Plexiglas model below.*

HUNTER PRESSED STEEL COMPANY, LANSDALE, PENNA.

HANSEN *Couplings*

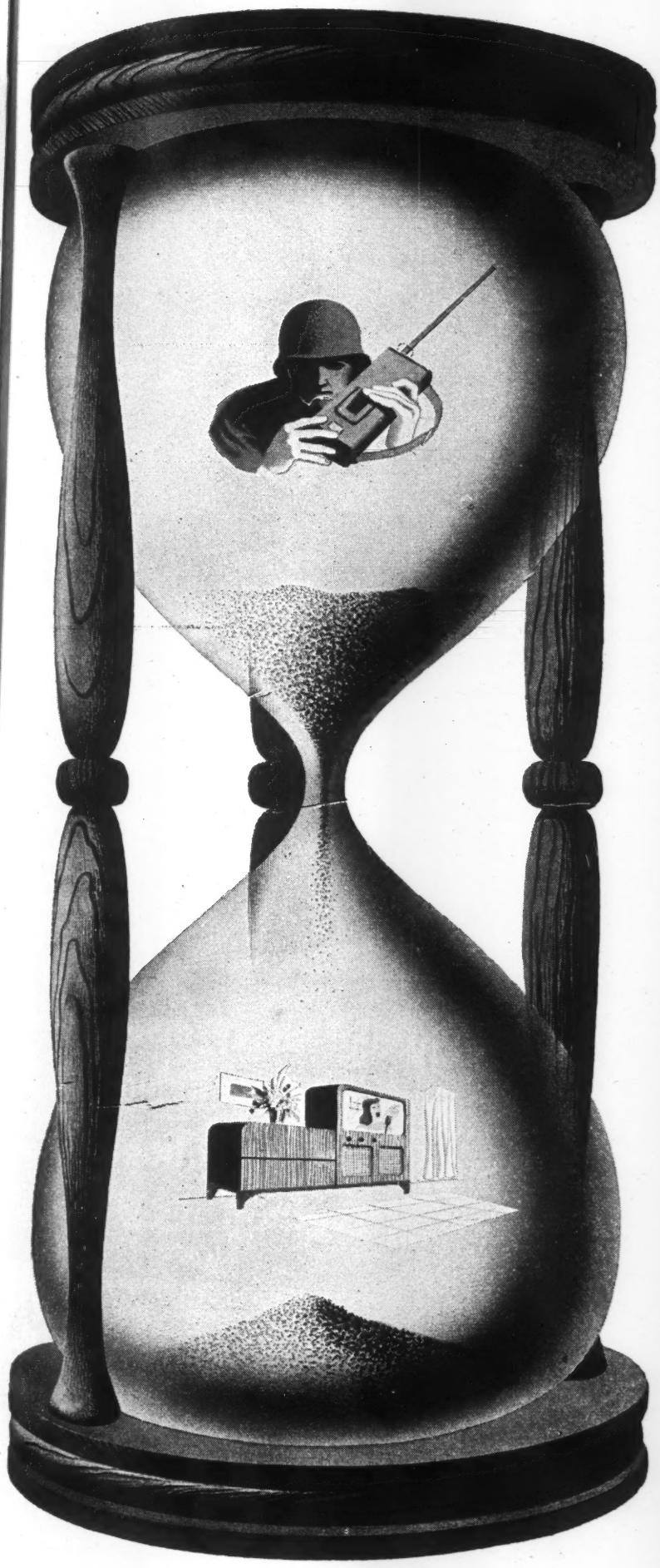
PACE PRODUCTION IN THE GREAT LOCKHEED PLANT!

The remarkable production records made in the great Lockheed plant are something to be proud of because here is peak production at low operating expense. ● Hansen couplings used throughout the Lockheed plant are a very important factor in piling up production records on the great Lockheed Lightning and the giant transport Constellation. ● With Hansen couplings it's speed, ease of operation, no wastage of time and no leakage which means a big savings in air. ● Hansen couplings are easy to operate; slight push of plug into socket, coupling is connected, air is automatically turned on. Easy pull on sleeve, coupling is disconnected, air is automatically turned off. No twisting, turning or locking; no kinking of hose and no jamming or freezing of parts. ● Hansen couplings are the most widely used couplings on the market due to their vastly superior performance and long life.

Write for free industrial catalog.

HANSEN MANUFACTURING CO.

1786 EAST 27th STREET • CLEVELAND, OHIO



WILCO facilities Expanded to Meet Wartime Needs!

But Postwar Industry will be the ultimate gainer from the many new WILCO products and developments

As the Hourglass indicates . . . at the coming of peace, the skill and experience gained in the development and application of new WILCO products and techniques will mean much to automotive, electrical appliance and many other types of manufacturing customers.

Though now chiefly applied to the war effort, these new WILCO developments are destined to play as vital a role in the postwar industrial "comeback" as they are now playing in scores of wartime applications.

Thermostatic Bimetals, Electrical Contacts, and Precious Metal Bimetallic Products are such important factors in the precision performance of ships, planes, tanks, guns, and various instruments of the Army and Navy that the H. A. Wilson Company has found it necessary to enlarge its facilities and develop these important new products and techniques.

In the postwar period no company will be better equipped to meet individual requirements for Thermostatic Bimetals and Electrical Contacts on any desired scale than the H. A. Wilson Company, pioneers in this field.

WILCO PRODUCTS ARE: *Contacts*—Silver, Platinum, Tungsten, Alloys, Sintered Powder Metal. *Thermostatic Bimetal*—High and Low Temperature with new high temperature deflection rates. *Precious Metal Collector Rings* for rotating controls. *Silver Clad Steel. Jacketed Wire*—Silver on Steel, Copper, Invar, or other combinations requested. *Rolled Gold Plate.* Special Materials.

THE H. A. WILSON COMPANY
105 Chestnut Street, Newark 5, New Jersey

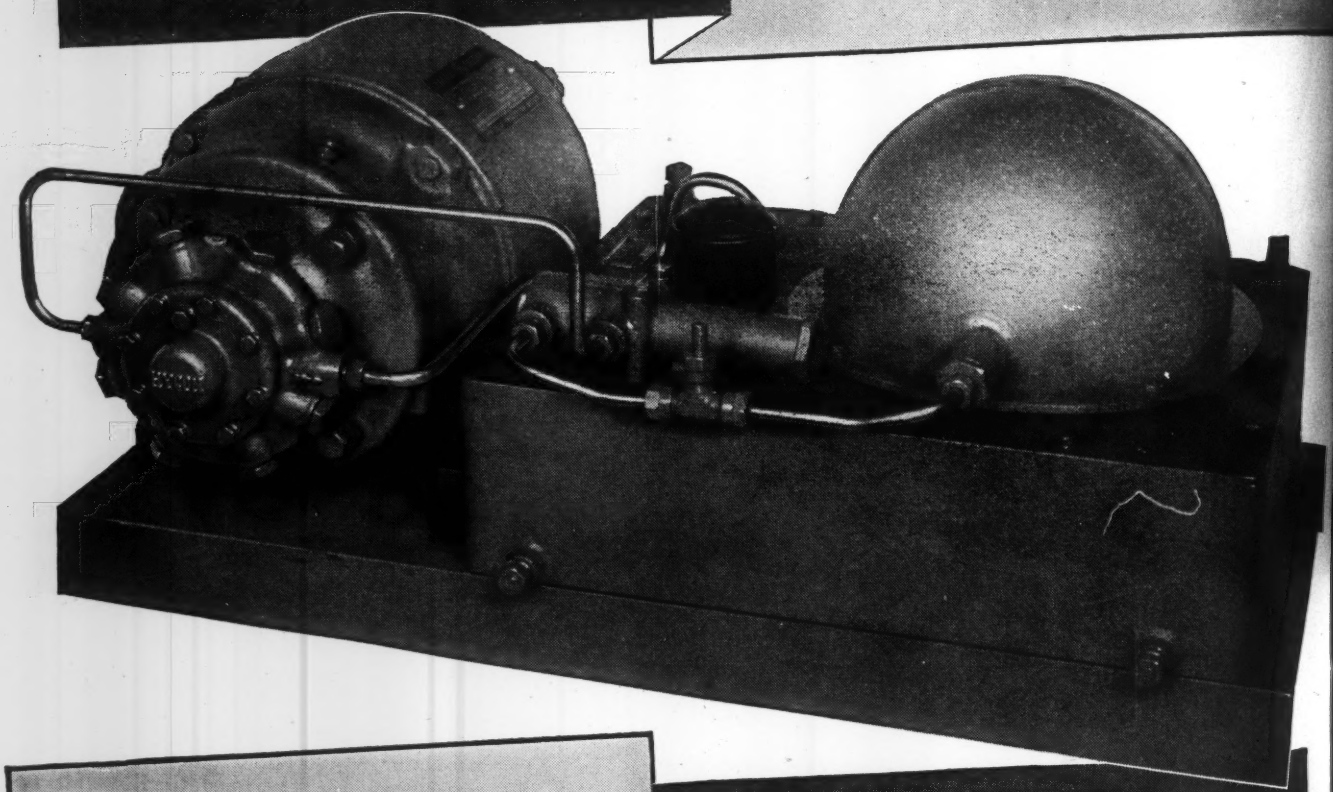
WILCO

Thermometals—Electrical Contacts
Precious Metal Bimetallic Products

HYCON

3000 p.s.i. Hydraulic Power Unit

3 HP Motor
8 cylinder Pump
Unloading Valve
Accumulator and Reservoir



A small compact unit for machine tools, hydraulic presses and test equipment

Quickly and easily installed for smooth reliable hydraulic operations up to 3000 p.s.i.

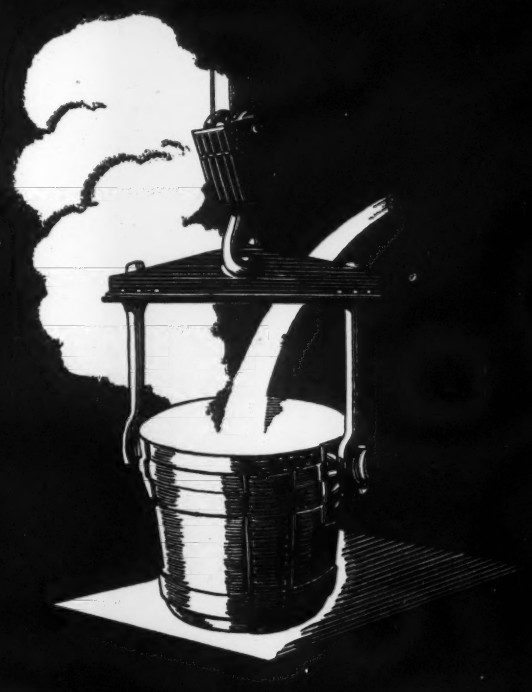
Specifications and Engineering Data on Request

THE NEW YORK AIR BRAKE COMPANY

Hydraulic Division

420 Lexington Avenue, New York 17, N. Y. Factories: Watertown, N. Y.

BETTER STEEL CASTINGS THROUGH RESEARCH



Substance and Flavor for the Stew

What comes out of the kettle depends upon what goes in. Good cooks know that. And so do today's good steel founders.

Research has outmoded "rule of thumb" methods. There is too much uncertainty in a "pinch of this and a pinch of that".

The exacting demands of industry—in both war and peace—have made a rigidly controlled science of preparing steel for castings.

Research has told us exactly what to add, and how much of it, to get hardness or toughness or elasticity or stamina. And how to enhance these desirable properties by heat treating.

We now have chemical controls and checks, regulated grain size and metal structure, mechanical properties that can be predetermined.

When certain alloying agents became subject to war scarcity, research again stepped in and developed new steels that were often better than the old ones.

As a result of the improved techniques and practices research has uncovered, our side has the finest weapons of war ever produced, and in the greatest plenty.

In this war production steel castings have had a very important share. Steel castings have saved both time and money, by adapting themselves to countless uses never dreamed of before.

So now, as an Industry, we are able to promise you that Steel Castings will be ready to perform a similar role in turning out improved tools and implements for living in peace.

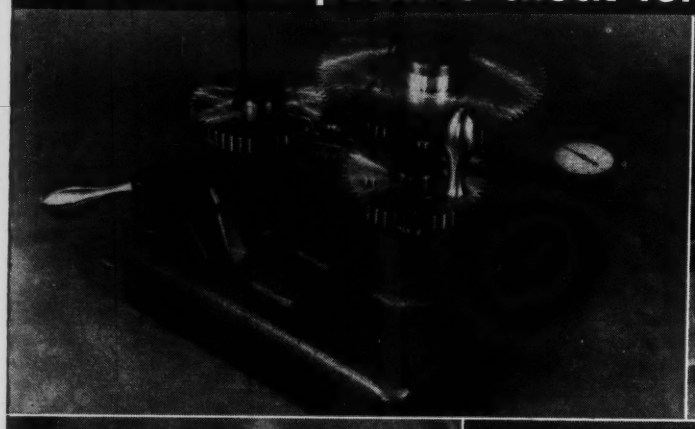
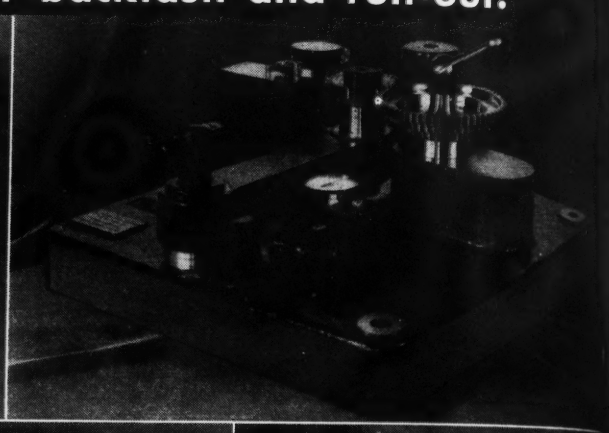
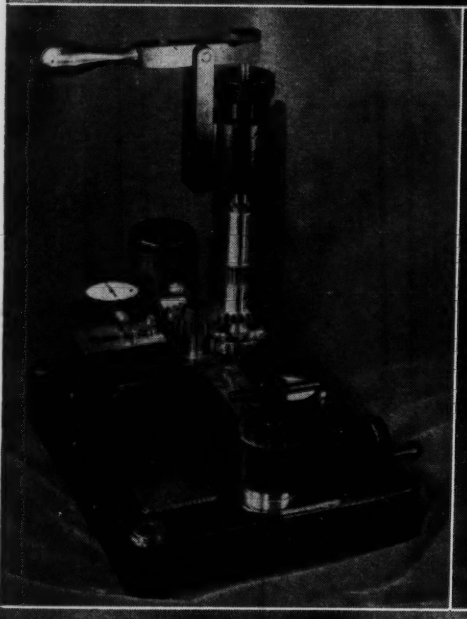
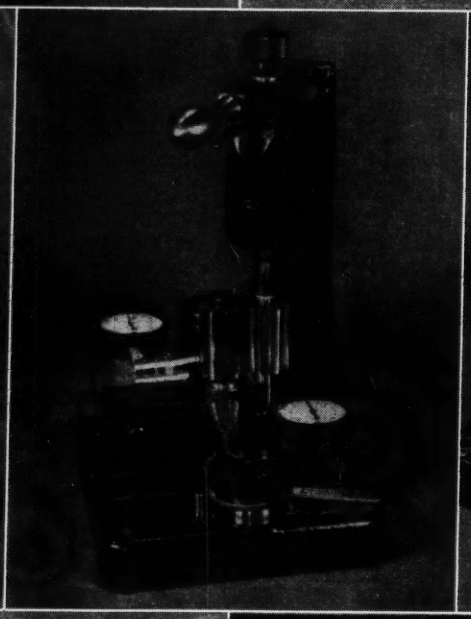
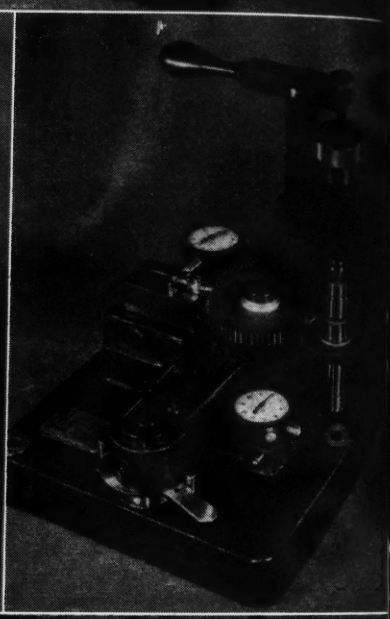
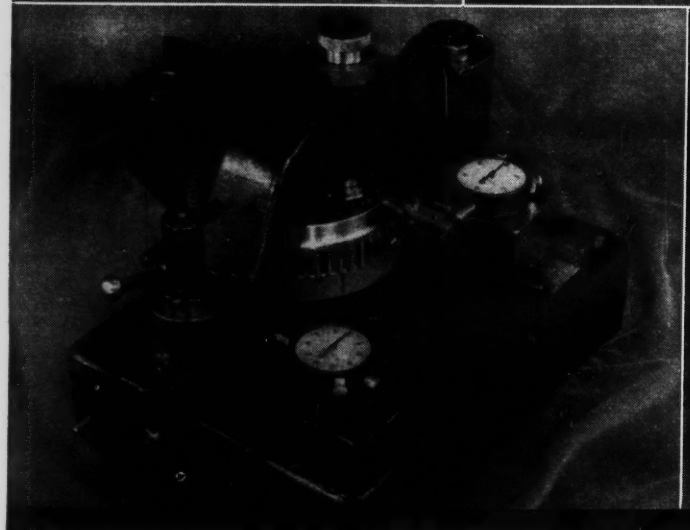
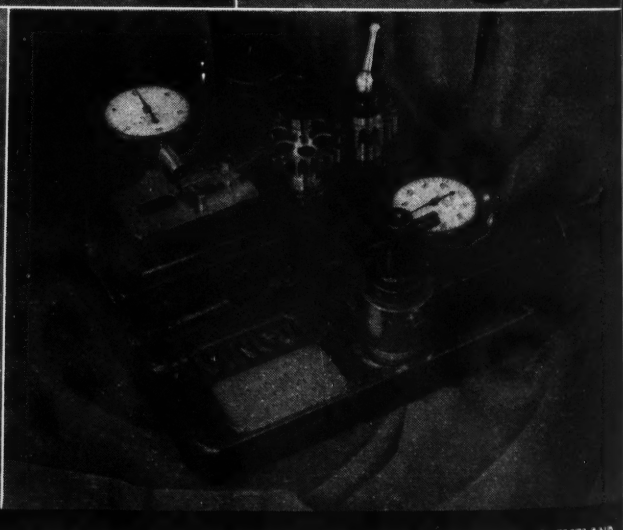
Published by the Steel Founders' Society of America, to tell you about its organized Research Program.

MODERNIZE AND IMPROVE YOUR PRODUCT WITH

STEEL CASTINGS

VINCO GEAR ROLLING FIXTURES *with* MASTER GEARS

. . . a positive check for backlash and run-out.

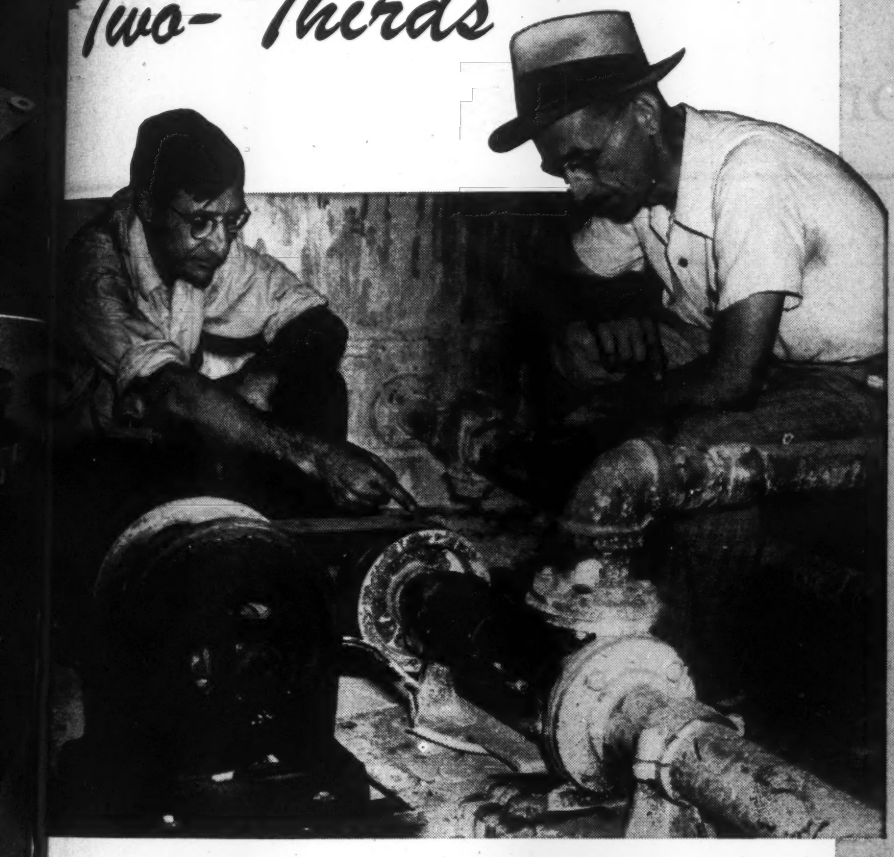








VINCO CORPORATION, 8875 SCHAEFER HIGHWAY, DETROIT 27, MICHIGAN, SALES OFFICES, NEW YORK, CHICAGO, CLEVELAND

MILLIONTHS OF AN INCH FOR SALE BY VINCO

Semi-Automatic Hydraulic Spline and Gear Grinder • Optical Master Inspection Dividing Head • Involute Checker • Angle Tangent to Radius Dresser • Index Plates • Precision Vises • Sine Bars • Straight-side Spline, Serration Spline, Involute Spline and Helical Spline Plug and Ring Gages • Thread Plugs, Rings and Setting Plug Gages • Spur and Helical Master Gears • Munition Gages • Propeller Hub Gages • Built-up and Special Gages • Gear Rolling Fixtures • Spline and Index Fixtures • Hydraulic Power, Control, Utilization and Distribution Units • Engineering, Design and Development

"It Cut Our Pumping Costs by Two-Thirds"



Ernest Frasier, Master Mechanic in charge of shop and maintenance, and W. A. Harding, Production Engineer, agree upon two things: that they pump one of the worst types of abrasives encountered in any industry; and that the R & M Moyno Pump does a far better job at far lower cost.

Over two years ago, the Jeffery-Dewitt Insulator Corp. of Kenova, W. Va., installed their first Moyno, and nine months ago they purchased their second. These two pumps replaced three centrifugals in handling high-flint-content "high ball clay slip." Both Moynos are in continual service six days a week and Mr. Frasier reports maintenance costs have been cut over sixty per cent.

In eliminating breakdowns the Moynos have reduced work stoppages by two-thirds while their faster pick-up, greater capacity, and longer life have accomplished an actual money saving of nearly seventy per cent.

The Moyno Pumps handle all types of particles better, including dirt, and have saved not only repairmen's time but the time of plant operators, as well.

HARD-TO-HANDLE MATERIALS HAVE MET THEIR MASTER

VIRTUALLY all fluids or semi-liquids—even mixtures containing as high as sixty-five per cent solids in suspension—are moved faster and more economically with an R & M Moyno Pump.

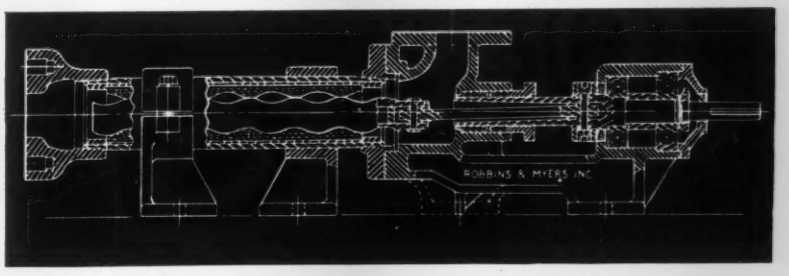
The Moyno is not even similar to any other type of pump, yet it combines the advantages of all in one simple, versatile design that keeps velocities low, smooth, and uniform while providing high reserve pressure and ability to pump practically anything that will flow through a pipe.

The revolutionary principle of the Moyno Pump assures both remarkable efficiency in pumping heavy viscous materials, and long-lasting durability in handling abrasives in suspension.

Whatever your pumping problem, it will pay you to investigate the R & M Moyno. Send for literature.

ONLY ONE MOVING PART

The R & M Moyno Pump has no valves or pistons, yet it is self-priming and delivers a uniform flow at high efficiency. The only moving part—a single-thread helical rotor—revolves within a double-thread helical stator, to provide pumping action comparable to that of a piston moving through a cylinder of infinite length. Diagram shows the Moyno Tubular Pump used at Jeffrey-Dewitt Insulator Corp., an excellent type for high pressures and severely abrasive conditions.

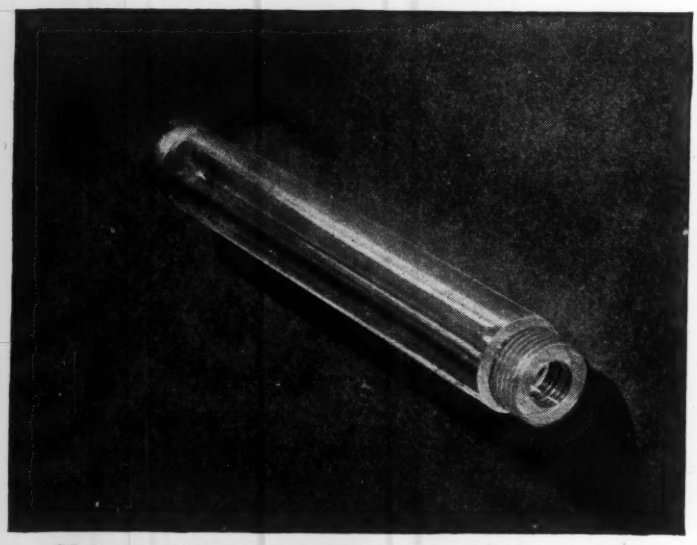


R & M MOYNO PUMP

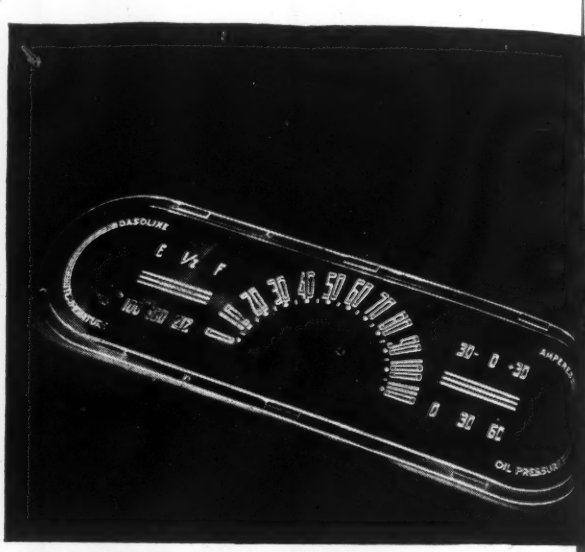
ROBBINS & MYERS, INC., *Moyno Pump Division*, SPRINGFIELD, OHIO • IN CANADA, Brantford, Ontario; Robbins & Myers Co. of Canada, Ltd.

MOTORS • HOISTS • CRANES • MACHINE DRIVES • FANS • MOYNO PUMPS

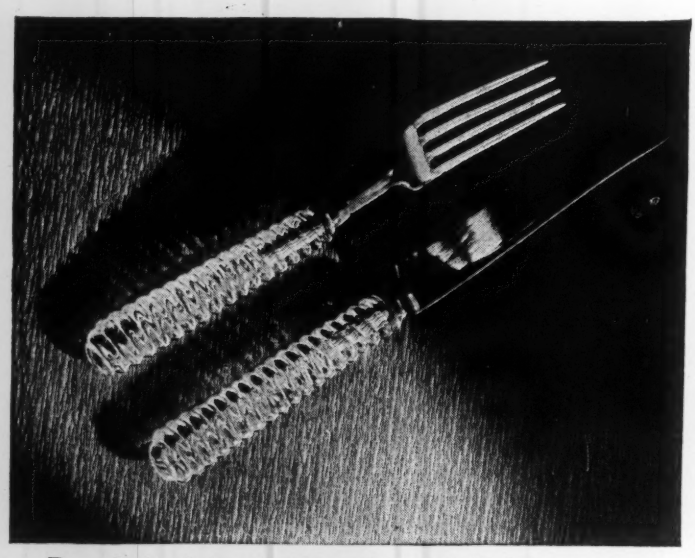
Crystal-clear Plexiglas...
is economical to mold



Mounting thread is molded into aircraft fuel gauge for easy installation.



Broad mounting rim simplifies assembly of edge-lighted automobile dial.



Rope design brings lively sparkle to molded PLEXIGLAS flatware handles.

Color applied to back of clear molding gives rich three-dimensional depth to molded-in design.

ROHM & HAAS

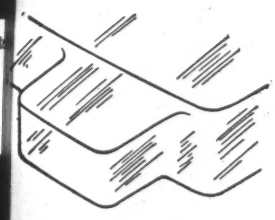
Manufacturers of Chemicals including Plastics . . . Synthetic Insecticides . . . Fungicides

..how to design for most effective use of this acrylic plastic

WHEREVER large numbers of identical parts are required, PLEXIGLAS moldings can offer cost economies, while presenting the same advantages—transparency, light weight, strength, chemical resistance—that characterize PLEXIGLAS sheets and rods.

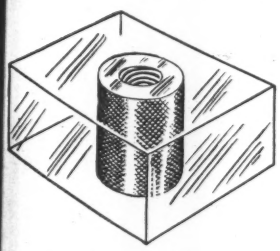
We recommend consultation with a reliable custom molder who can assist you in making the best use of the plastics molding process. In addition, the following may be helpful in designing moldings of transparent, crystal-clear PLEXIGLAS.

1. Mold mounting lugs, rims or threads into part to cut assembly costs.



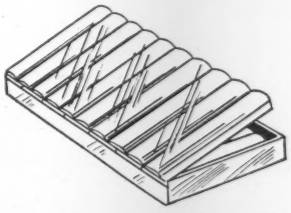
By molding mounting devices as part of the dials, dial covers, and similar transparent parts, it is often possible to eliminate gaskets, bezels and other assembly parts and to reduce finishing time. Lugs and rims should be as substantial as possible. Threads should preferably be heavy and coarse.

2. Use metal inserts, when required, as decorative part of molding.



If part requires adjustment or will be frequently disassembled, a metal insert is usually preferable to a molded-in thread. Allow for sufficient PLEXIGLAS around the insert to anchor it firmly. The *exterior* of the insert should be properly designed and finished, since it will be visible through transparent PLEXIGLAS.

3. Consider sparkling surface effects for parts which will be subjected to scratching in service.



Where appearance is a factor, breaking the surface of PLEXIGLAS into a number of polished facets, flutes or reeding takes full advantage of the lively sparkle of the material and also reduces the visibility of any slight surface scratches the molding may receive if handled roughly.

LOOKING AHEAD THROUGH

Plexiglas

The familiar bomber nose is a PLEXIGLAS nose. PLEXIGLAS was developed in Rohm & Haas laboratories, first brought to commercial production in Rohm & Haas plants. Today it is found on every type of Army and Navy plane—convincing proof of the qualities that have made it "aviation's standard transparent plastic."

Why not investigate the ways in which it can give *your* product new sales advantages? Write or call our nearest office—Philadelphia, Detroit, Los Angeles, Chicago, Cleveland, New York. Canadian Distributor, Hobbs Glass Ltd., Montreal, Quebec.

Only Rohm & Haas makes

PLEXIGLAS

CRYSTAL-CLEAR ACRYLIC SHEETS, RODS AND MOLDING POWDERS*

*Formerly CRYSTALITE Molding Powders

PLEXIGLAS is the trade-mark, Reg. U.S. Pat. Office, for the acrylic resin thermoplastic sheets, rods and molding powders manufactured by Rohm & Haas Company.

C O M P A N Y

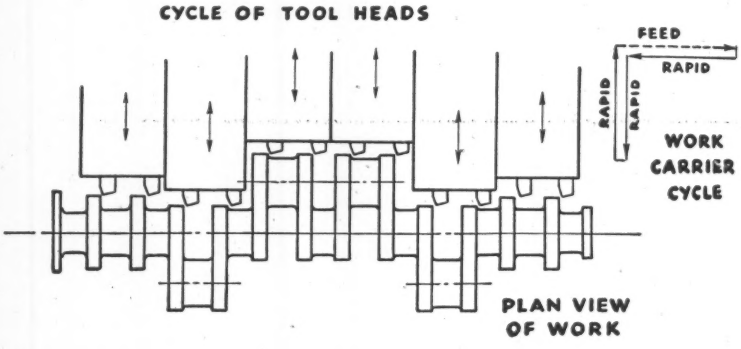
WASHINGTON SQUARE
PHILADELPHIA 5, PA.

Enzymes . . . Chemicals for the Leather, Textile, Enamelware, Rubber and other Industries

SUNDSTRAND
HYDRAULIC UNITS

Use them to simplify your machine-design problems!

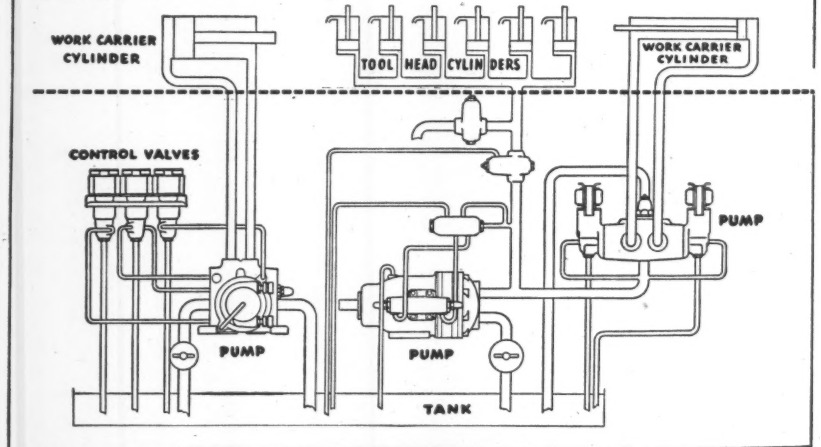
The top drawing is a diagram of the tool and work cycles actuated by Sundstrand Hydraulics on a Wickes Brothers Heavy Duty Contour Turning Lathe which forms the elliptical crank arms on a large multiple throw crankshaft. The diagram below shows the units and piping of the Sundstrand "tank unit" and the associated cylinders in the machine.



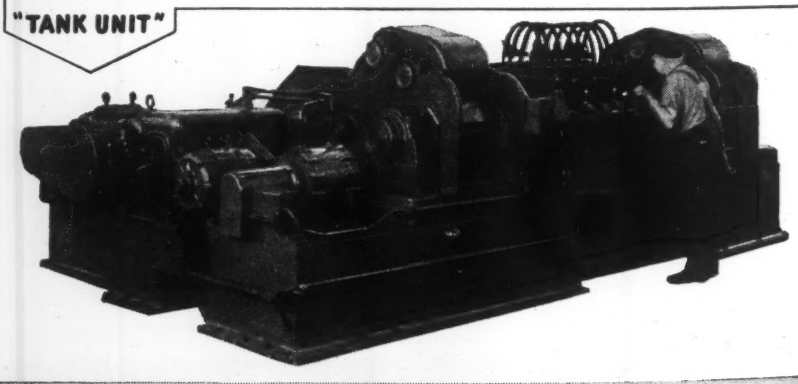
HERE IS HOW WICKES BROTHERS USE SUNDSTRAND HYDRAULICS ON A CONTOUR TURNING LATHE

Illustrated here is a machine-design problem which was greatly simplified by the application of Sundstrand Hydraulics. Six tools independently form specified contours and the work is put through a cycle involving both lateral and longitudinal movements at rapid and working feeds. As shown in the diagram above, the contour movement of each tool is governed by holding the tool carrier against a contour cam with hydraulic pressure. Work carriage movement is governed by two hydraulic cylinders. Motivation for all of these movements comes from the Sundstrand "tank unit".

Movement of six tool heads and work carrier cycle provided by single Sundstrand tank unit.



"TANK UNIT"



A COMPLICATED CYCLE MADE EASY

To control and drive this machine by mechanical or electrical units would necessitate extremely complicated and troublesome mechanisms. Sundstrand Hydraulics can take the "grief" out of many machine-drive design problems, as was done here. Let Sundstrand furnish your power drive and controls. *Get acquainted with Sundstrand Hydraulics!*

SUNDSTRAND PUMP DIVISION

SUNDSTRAND MACHINE TOOL CO. ROCKFORD, ILLINOIS U.S.A.

2556 ELEVENTH ST.
ROCKFORD, ILLINOIS

Exact Contour Hardening

in 2/3 of a SECOND

with -MEGATHERM-*

ELECTRONIC HEAT

Here's another difficult hardening job, done simply and quickly with Megatherm.

Exact contour hardening of the inner gear of these supercharger clutch discs was done in less than ⅔ of a second each.

These gears were hardened to a depth of .050", with the hardening closely following the tooth and root contour of the gear surface, without affecting the strength or ductility of the remaining metal. The unretouched photograph above tells the story.

To do this contour hardening a jig was built to support the disc so that its inner surface surrounded a two-turn induction coil, directly connected to the output terminals of the 25 kw Megatherm.

The Megatherm automatic timer limits the heat period to exactly ⅔ of a second, then operates a solenoid which trips the disc into an oil-quench bath.

Here is another example of Megatherm's adaptability to many hardening problems involving irregular and "hard-to-get-at" surfaces.

If you have a surface hardening problem . . . whether for wartime or peacetime application . . . consult Federal's Megatherm engineers for the answer or write for complete data.

FEDERAL TELEPHONE & RADIO — FTR

Federal Telephone and Radio Corporation

*REG. AND PAT. TRADE MARK

INDUSTRIAL ELECTRONICS DIVISION

AN IT&T ASSOCIATE

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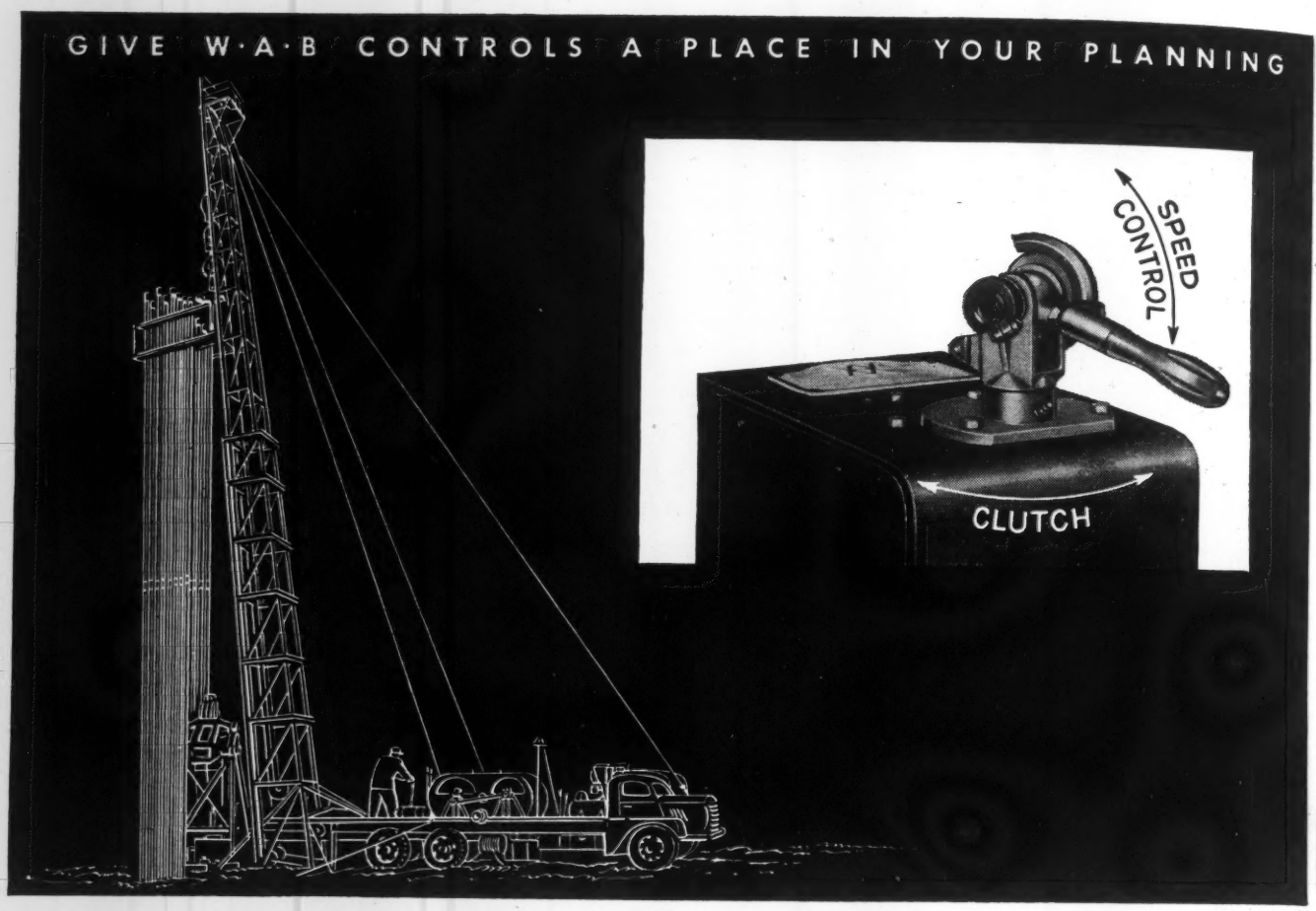
GIVE W·A·B CONTROLS A PLACE IN YOUR PLANNING



A "TWIST OF THE WRIST"

governs speed and clutch through

W·A·B controls

Here's a control that gives a new and literal meaning to an old familiar expression. For with an actual "simple twist of the wrist," the operator governs speeds and clutching on this modern oil service rig.

Swinging the control lever to right or left actuates the clutches. Moving the handle through a horizontal arc precisely varies the engine speed. This simple, positive, effective device is another example of the magic of air in solving remote control problems.

75 Years of Pioneering

1869 1944

W·A·B Remote control systems are handling all sorts of jobs, from simple "push and pull" up to entire series of interlocked operations. If you—in your present work or your post-war planning—have a place where an engineered, service-tested remote control system is needed, you'll find it profitable to give W·A·B devices a place in your planning.

Westinghouse Air Brake Company

INDUSTRIAL DIVISION

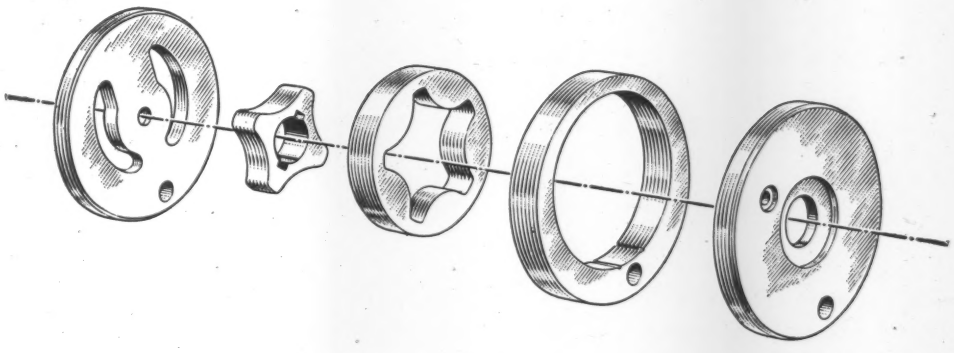
General Offices: Wilmerding, Pa.

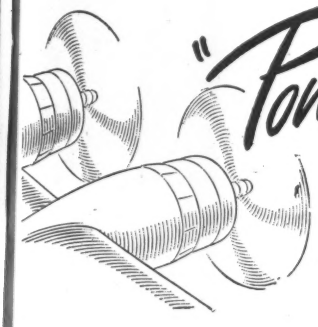
W·A·B

Pneumatic · Pneumatic Electric · Pneumatic Hydraulic

remote control systems

ANOTHER MASS-PRECISION ASSEMBLY BUILT BY NICHOLS





"Power House" in a Mass-Precision Package

Operating at 4,000 R.P.M. and delivering oil at 1,200 P.S.I. may sound like a "tall order" for this small assembly of parts. Yet these requirements headed the list when a leading aircraft equipment manufacturer asked Nichols to produce an interchangeable precision unit which would power hydraulically the feathering action of a propeller in every extreme of temperature.

Feathering a propeller calls for "flick-of-the-switch" response from this mechanism to deliver full pressure *instantly* to stop "windmilling."

Trouble-free performance such as this depends on extremely fine finish and critical dimensions in every part.

Here's how Nichols is producing this "precision package": Flatness and parallelism of the two sides are held to .00015″ over a two-inch span...thickness of the gerotors to ±.0001″...special lapping provides high surface finishes even on the rolled bronze part where normal lapping methods would charge the surface. All parts are assembled without pre-selection—which means low-cost production—and are enclosed in a housing.

The solution to one of your product problems may be found in introducing into your design the same basic idea that proved so successful here: localizing the difficult-to-make precision unit in a self-contained, removable assembly which does not depend on the housing for clearances and close fits. Then let "Accurate" Nichols build it.

W. H. NICHOLS & SONS, 48 WOERD AVENUE, WALTHAM 54, MASS.

"Accurate" Nichols

PRECISION ENGINEERING AND MANUFACTURING FACILITIES FOR MASS PRODUCTION.....

SHOCK is the foe of machinery. SHOCK and resultant VIBRATION caused by metal-to-metal contacts of moving parts are fast being eliminated by modern processes of rubber-to-metal adhesion.

A "striking example" of metal-to-metal *versus* rubber-to-rubber contacts is the development of the modern combine or "all-crop harvester."

ORCO engineers, working closely with farm machinery engineers, applied modern rubber adhesion processes to eliminate metal-to-metal contacts in threshing mechanisms.

The "end result" was elimination of SHOCK which in old style harvesters limited the machines to hard shell crops and often caused damage to both crops and machines.

Rubber-to-rubber contacts now widen the scope of the modern combine to include soft shell as well as hard shell crops. Machines last longer. Crops are protected against crushing. Operators are relieved of fatigue caused by excessive noise and vibration.

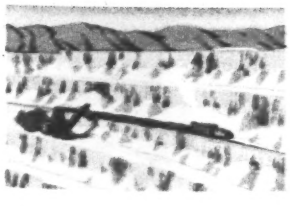
When YOU encounter problems involving SHOCK and VIBRATION in moving parts of machinery, ORCO engineers are prepared to co-operate. Ask for ORCO-OPERATION!

"ORCO-OPERATION"

THE OHIO RUBBER COMPANY · WILLOUGHBY, OHIO

BRANCHES: DETROIT • NEW YORK • CHICAGO • INDIANAPOLIS • WASHINGTON • CLEVELAND

REPORTING *on the use of Linde Methods in mass production . . .*



Production and Fabrication of Steel . . . *through the entire cycle from mining to scrapping,* LINDE METHODS *are important*

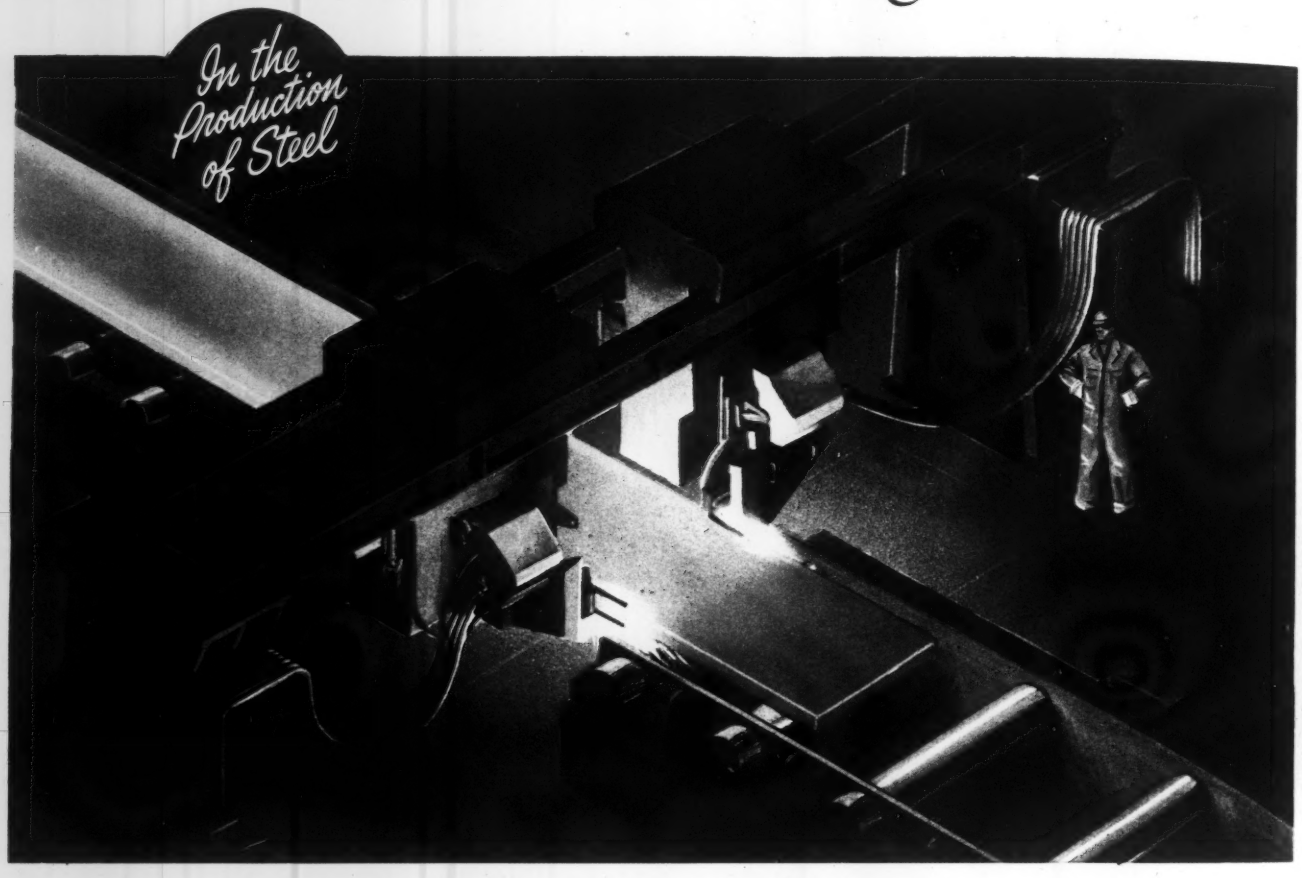
The oxy-acetylene processes shown here—flame-cutting, flame-cleaning, flame-gouging, welding, and hard-facing—are a few of the many Linde processes that are important in the entire cycle of steel. In iron mines . . . in mills where steels are made . . . in fabricating shops . . . even in scrap yards where worn-out equipment is prepared for further service . . . Linde developments help to speed production and lower costs.

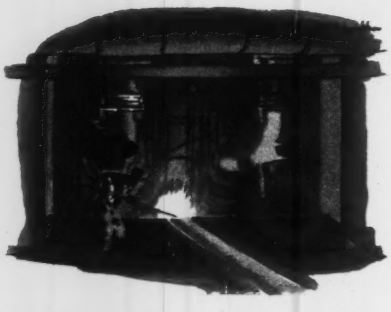
In this mine maintenance shop, for example, the equipment is kept in good operating condition by the use of some of these Linde processes. The portable oxy-acetylene cutting machine used here to reclaim a worn locomotive wheel is also used to produce steel shapes from stock steel.

There are other Linde methods to help maintain production . . . methods for hard-facing parts such as dipper teeth . . . for gouging out cracks in castings to prepare them for welded repair . . . and for flame-priming structural steel and plate to make paint last longer when it is applied.

In the next three pages you can learn more about the use of Linde-developed processes in the mass-production of steel and things made of steel.

LINDE Metalworking Methods

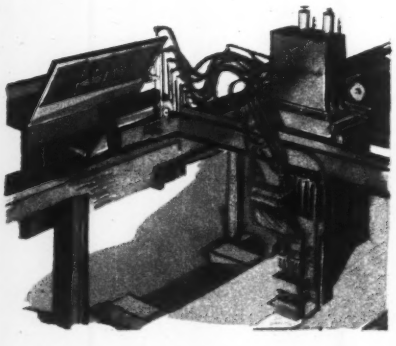




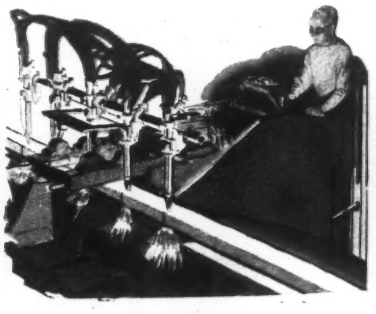
Furnace-Tapping—By use of the oxygen lance to clear the tap hole, the opening is quickly made for molten iron or steel to pour from the furnaces.

MECHANIZED HOT-SCARFING — The removal of surface defects from semi-finished steel once entailed removing the hot steel from the production line . . . allowing it to cool . . . treating it to make defects visible . . . or chipping out these defects . . . and then reheating the steel for further processing. Today, through use of Linde equipment, mechanized batteries of oxy-acetylene blowpipes located on the roll tables literally "skin" faulty surfaces from the hot steel . . . and higher yields of quality steel are obtained without interruption of production.

Deseaming — Where mechanized conditioning of steel is not feasible, or for secondary conditioning, Linde's manually operated flame-scarfing equipment is used.

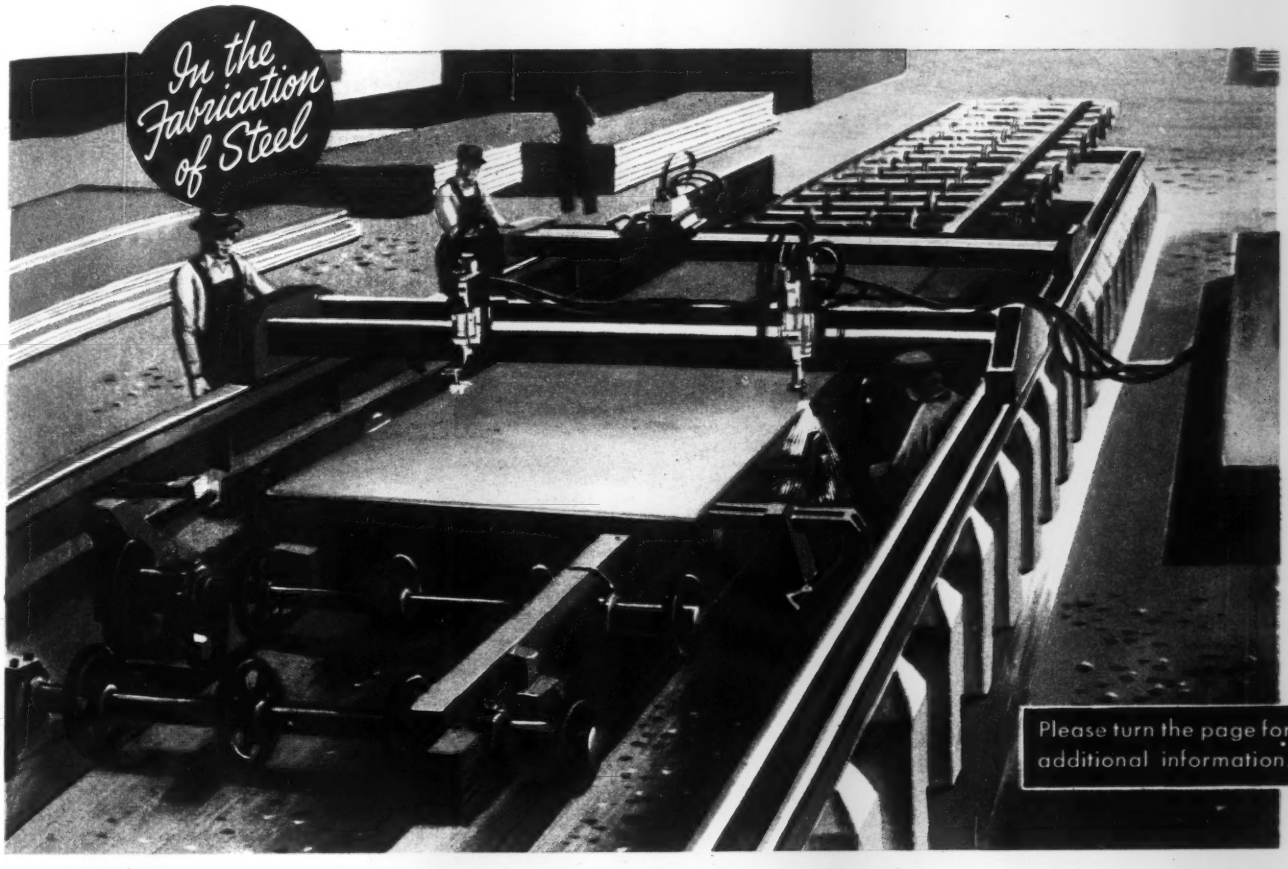


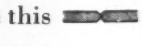
Mechanized Cold-Scarfing—Some special steels, such as slabs of armor plate, are allowed to cool before scarfing by Linde machines that move along the slab.

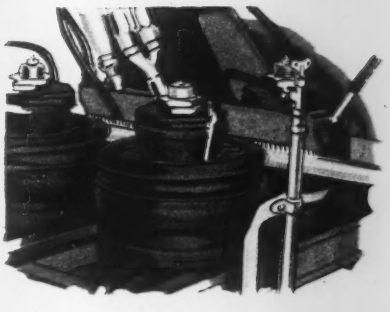


Billet-Cutting — Flame-cutting machines developed by Linde are used in the production line to cut billets and bars to length quickly, several pieces at a time.

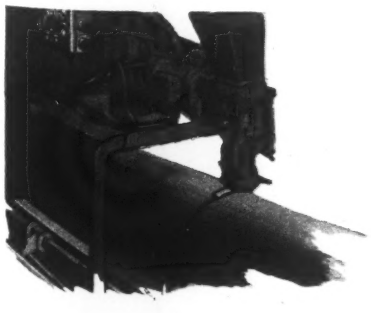
. . . Save Time and Materials



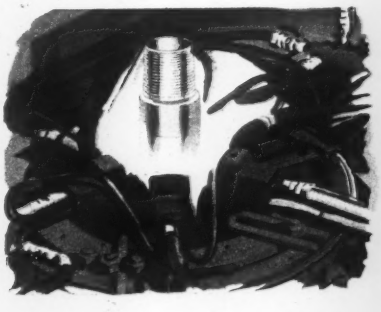
MECHANIZED FLAME-CUTTING — For shaping steel in the fabrication of industrial machines and equipment oxy-acetylene cutting is effecting important savings, both in time and in materials. The oxy-acetylene flame quickly and accurately slices through steel in straight lines, circles, or irregular shapes . . . work that otherwise would require massive machines. Linde engineering skill has helped adapt this "knife that never dulls" to high-speed work like the flame-planing of ship steel shown here. In one operation plate edges are trimmed to exact size and beveled like this  for welding.



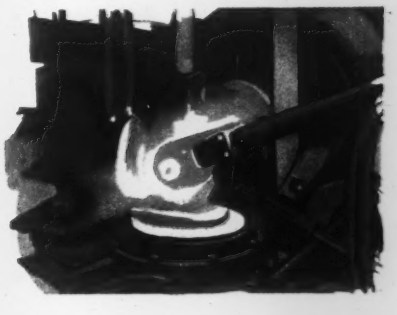
Tube-Welding—In making welded tubing, edges of steel strip moving at high speeds through forming rolls are joined by oxy-acetylene flames.



Unionmelt Welding—Linde's automatic electric welding process makes high-quality welds in steel of any thickness at unusually high speeds.



Flame-Hardening — Oxy-acetylene flames, followed by a water quench, impart a hard, wear-resistant case to surfaces of carbon or alloy steel parts.



Flame-Spinning — Tubing heated by oxy-acetylene flames while spun rapidly can be quickly end-formed to eliminate deep-drawing operations.

LINDE METHODS help to complete the cycle of steel and things made of steel

On the three preceding pages you have seen how Linde-developed processes and equipment speed the production of steel and things made of steel . . . from the mining of ore through all phases of fabrication. When steel products have served their useful life, oxy-acetylene processes help to complete the steel cycle. Flame-cutting with manually operated blowpipes is a fast and economical way to reduce steel to pieces of the right size for charging into furnaces for the production of new steel. During this work, many usable parts and steel sections can be salvaged for reclamation by welding and put back into service.

In whatever way you may work with steel it is likely that Linde engineering skill can help you adapt the oxy-acetylene flame to your operations.

The folders shown at the left tell the story of the use of Linde methods in SHIPBUILDING, in STEELMAKING, in METAL-FABRICATING, and in the production of PIPE. Copies will be sent to you upon request. Ask for Combination "B".

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PRODUCTION ACHIEVEMENT

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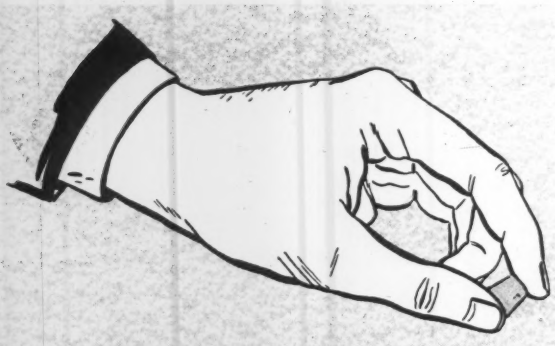
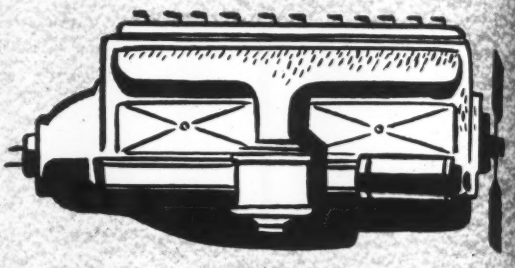


By protecting the fine orifices in Diesel engine injector nozzles from dirt in the fuel, Moraine Porous Metal filter elements safeguard engine performance and reduce maintenance in Diesel equipment of all types. Moraine Porous Metal is particularly qualified for this application by these characteristics: 1) Unique structure, attained by powder metallurgy, which provides tortuous flow passages for more efficient filtration. 2) Adaptability to fabrication in the most efficient shape. 3) Strength and ductility that permit press fits. 4) Adaptability to bonding so that the filter element and sealing gasket are an integral unit.

NO BIGGER THAN THE TIP OF YOUR FINGER

Yet This Unique Filter Element Is an Important Factor in Diesel Performance



MORAINE POROUS METAL

(Commonly known as POREX)

Moraine Porous Metal (Porex) is a unique product of powder metallurgy. It is made in four basic grades of fineness, with almost infinite graduations between them, and is available in varied shapes to meet design requirements.

If your product involves the flow of air, liquid or gases—as either an actuating medium, a combustion medium or a lubricating medium—you should find out what Moraine Porous Metal can do to improve your product's performance and extend its operating life. Moraine Porous Metal is performing varied functions for many industries—automotive, aviation, refrigeration, petroleum, pneumatic tool, industrial equipment, tractor, electric motor and others. Consult the Moraine Products Engineering Department for recommendations.

FILTRATION
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BREATHER VENTS
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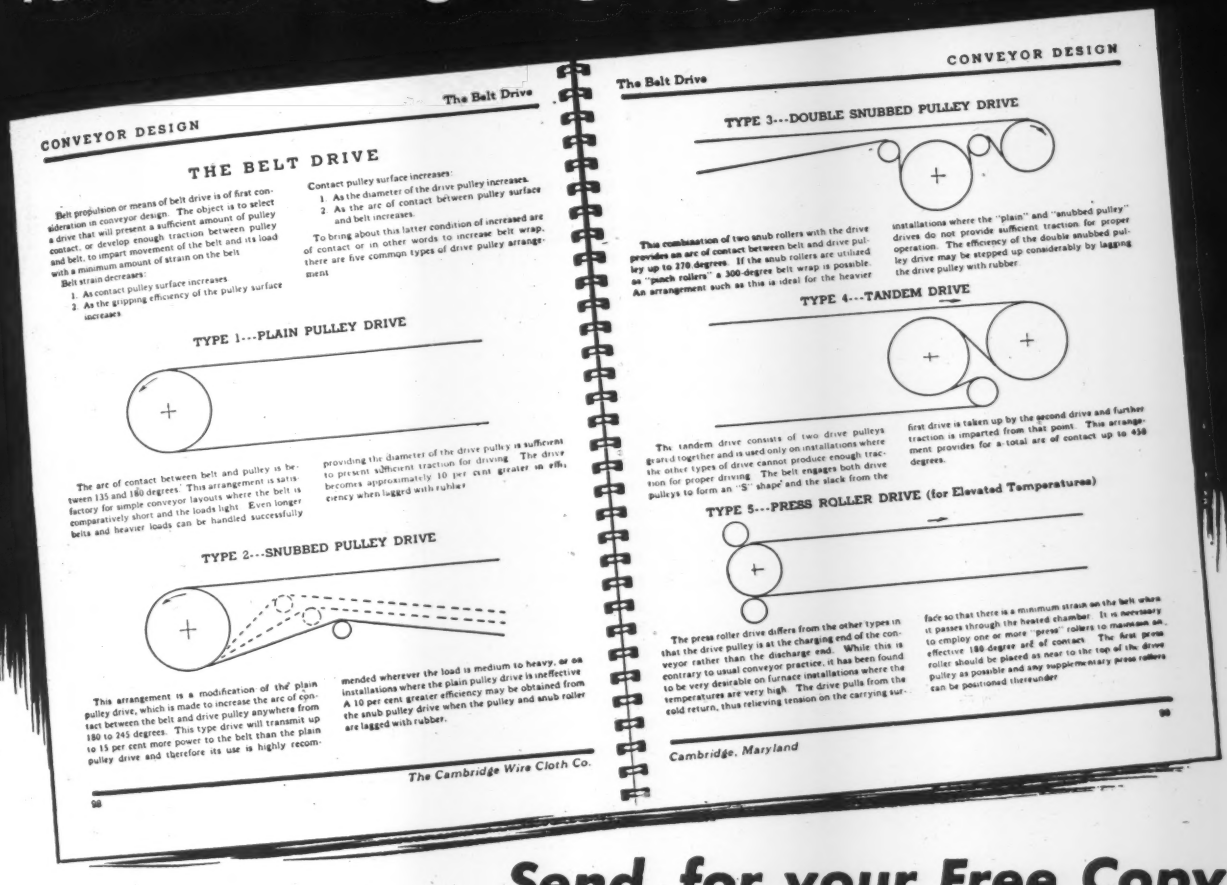
BUY WAR BONDS—SAVE LIVES

MORAINE PRODUCTS DIVISION OF **GENERAL MOTORS**
DAYTON, OHIO

HERE'S VALUABLE INFORMATION
for The Designing Engineer



CONVEYOR DESIGN — The Belt Drive

THE BELT DRIVE

Belt propulsion or means of belt drive is of first consideration in conveyor design. The object is to select a drive that will present a sufficient amount of pulley contact, or develop enough traction between pulley and belt, to impart movement of the belt and its load with a minimum amount of strain on the belt.

Belt strain decreases:
1. As contact pulley surface increases.
2. As the gripping efficiency of the pulley surface increases.

Contact pulley surface increases:
1. As the diameter of the drive pulley increases.
2. As the arc of contact between pulley surface and belt increases.

To bring about this latter condition of increased arc of contact or in other words to increase belt wrap, there are five common types of drive pulley arrangement.

TYPE 1---PLAIN PULLEY DRIVE

The arc of contact between belt and pulley is between 135 and 180 degrees. This arrangement is satisfactory for simple conveyor layouts where the belt is comparatively short and the loads light. Even longer belts and heavier loads can be handled successfully providing the diameter of the drive pulley is sufficient to present sufficient traction for driving. The drive becomes approximately 10 per cent greater in efficiency when lagged with rubber.

TYPE 2---SNUBBED PULLEY DRIVE

This arrangement is a modification of the plain pulley drive, which is made to increase the arc of contact between the belt and drive pulley anywhere from 180 to 245 degrees. This type drive will transmit up to 15 per cent more power to the belt than the plain pulley drive and therefore its use is highly recommended wherever the load is medium to heavy, or on installations where the plain pulley drive is ineffective. A 10 per cent greater efficiency may be obtained from the snub pulley drive when the pulley and snub roller are lagged with rubber.

The Cambridge Wire Cloth Co. — 98

The Belt Drive — CONVEYOR DESIGN

TYPE 3---DOUBLE SNUBBED PULLEY DRIVE

This combination of two snub rollers with the drive provides an arc of contact between belt and drive pulley up to 270 degrees. If the snub rollers are utilized as "punch rollers" a 300-degree belt wrap is possible. An arrangement such as this is ideal for the heavier installations where the "plain" and "snubbed pulley" drives do not provide sufficient traction for proper operation. The efficiency of the double snubbed pulley drive may be stepped up considerably by lagging the drive pulley with rubber.

TYPE 4---TANDEM DRIVE

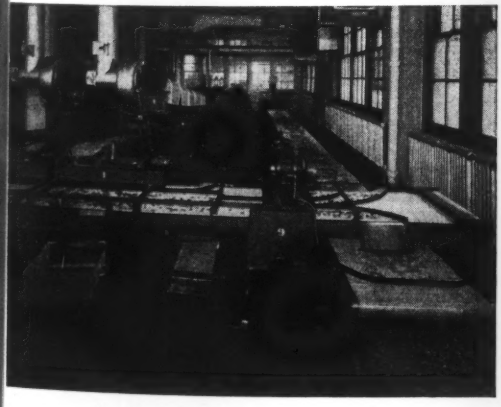
The tandem drive consists of two drive pulleys geared together and is used only on installations where the other types of drive cannot produce enough traction for proper driving. The belt engages both drive pulleys to form an "S" shape and the slack from the first drive is taken up by the second drive and further traction is imparted from that point. This arrangement provides for a total arc of contact up to 450 degrees.

TYPE 5---PRESS ROLLER DRIVE (for Elevated Temperatures)

The press roller drive differs from the other types in that the drive pulley is at the charging end of the conveyor rather than the discharge end. While this is contrary to usual conveyor practice, it has been found to be very desirable on furnace installations where the temperatures are very high. The drive pulls from the cold return, thus relieving tension on the carrying surface so that there is a minimum strain on the belt when it passes through the heated chamber. It is necessary to employ one or more "press" rollers to maintain an effective 180 degree arc of contact. The first press roller should be placed as near to the top of the drive pulley as possible and any supplementary press rollers can be positioned thereunder.

Cambridge, Maryland — 99

Send for your Free Copy
CAMBRIDGE CONVEYOR BELT MANUAL



Typical Cambridge Conveyor Belt installation in the Food Industry

THIS technical book contains pertinent information on all types of belt installations. Useful as reference in redesigning present installation or in planning future uses. It contains full details about Cambridge Conveyor Belts outstanding for their economy in that they permit treatment of the product simultaneously with its movement on the belt.

Thousands of Cambridge Conveyor Belts are today being successfully used in many industries:—Processing, Mechanical, Food, Glass, Ceramic and Metal Working.

Write for booklet or more information to Dept. 20.

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PANELYTE floorings

save weight... assure required strength

Used on the Martin Mars

PANELYTE Aircraft Flooring, molded of high-strength, laminated phenolic plastic, weights approximately ¼ *pound less per square foot than* other floorings of equal strength and capacity. Developed by the Glenn L. Martin Company and installed in the Martin Mars, this new type flooring consists of a flat top surface molded to a web, which, for greater strength, may be reinforced with aluminum alloy inserts. The non-skid, morocco top finish lightens the plane by eliminating the need for floor covering. Requiring no special procedure or bracing, it is quickly installed. It is supplied in 11 grades to meet varying strength requirements.

Used on the Martin B-26

PANELYTE Heavy Duty Cargo Flooring is ideal where plane loading surfaces are subjected to abnormal stress and strain. Designed to withstand the abuse of loading and unloading tanks, machinery, etc., this shock-proof flooring is constructed of high-strength PANELYTE cured to the top and bottom of a tough plywood core. Easily fabricated by standard wood-cutting tools, PANELYTE Cargo Flooring is shipped ready for installation. The morocco top surface does away with labor and expense of providing and fitting floor covering. Rugged, yet light in weight, this flooring meets cargo service specifications.

Samples and data on these light weight PANELYTE floorings furnished on request. Our Engineering Staff will be happy to assist in the design of laminated plastic parts for mass production. Write for "Data Sheets".

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WHATEVER your product and whatever its power requirements, it will benefit by the *long life and dependability* that are built into Delco motors. These qualifications—known to millions of appliance users and appreciated by thousands of appliance dealers—are based on Delco Products' long experience in manufacturing electric motors to meet specific requirements.

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Delco Products has worked closely with leading manufacturers of refrigerators, washers, ironers, oil burners, stokers, air conditioners and other motor-driven products, to achieve the most satisfactory motor for each type of application.

This know-how, backed by the research and manufacturing facilities developed through years of service, is ready to be applied to your specific problems.

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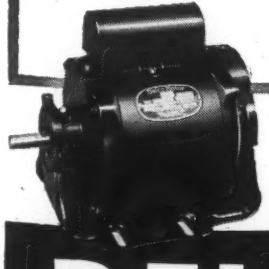
During the war, Delco Products has built thousands of precision electric motors to meet the needs of the aircraft industry . . . fuel pump motors, machine gun mount motors, windshield wiper motors, defroster fan motors and motors for precision instruments. The technological progress and intensive research involved in this assignment—together with improved manufacturing methods and increased facilities—promise continued leadership for Delco Products in the development of better motors for all types of products.



Shorten the War—with MORE WAR BONDS

DELCO MOTORS

DIVISION OF GENERAL DELCO PRODUCTS DAYTON, OHIO MOTORS CORPORATION

KIPP
Featherweight
AIR GRINDER

The Model [illegible] new in design both inside and outside. [illegible] utilized fewer parts and they are [illegible] of Magnesium and Aluminum for [illegible] featherweight lightness. The [illegible] shaft diameter is unusually large [illegible] smoothand true operation. [illegible] still longer wheel life and better [illegible] speed as before, is governed [illegible] and there are selected ball [illegible] rear. The JA Featherweight is a distinct improvement over all models previously produced by Madison-Kipp, the originators of really high speed grinders.

The same low price, $29.75 in U.S.A., remains. It is a post-war design for which materials have been released early. The pre-announcement output was geared to expected demand. Deliveries will be made out of stock as long as possible.

by

MADISON-KIPP

MODEL JA

50,000 R.P.M.

$29.75 in U.S.A.

NOTE:—Higher speeds at higher prices are available if supporting engineering data are submitted. Higher speeds are not recommended unless properly supervised.

Weight 12 ounces; Length 6¾ inches; Chuck Size ⅛ inch.
Wheel Guard Removed for Better Illustration

Nearly everyone in the mechanical industries knows about or uses Kipp Air Grinders. The Kipp announcement nearly fifteen years ago of the first hand grinder which turned 40,000 R.P.M. was a welcome surprise to tool makers. They always knew mile-a-minute surface speed was needed to remove metal instead of excessively rubbing down grinding wheels with slower speeds. The Kipp Air Grinder was the solution to the long standing grinding problem of getting into small places with small wheels.

The new Kipp Featherweight Grinder was made ready for post-war production. It can be sold now only because Aluminum and Magnesium have been more widely released. This post-war product, designed to meet all comers, can therefore be used in the continuing war jobs and for civilian jobs whenever they can be started.

Please include priority information in your wire orders.

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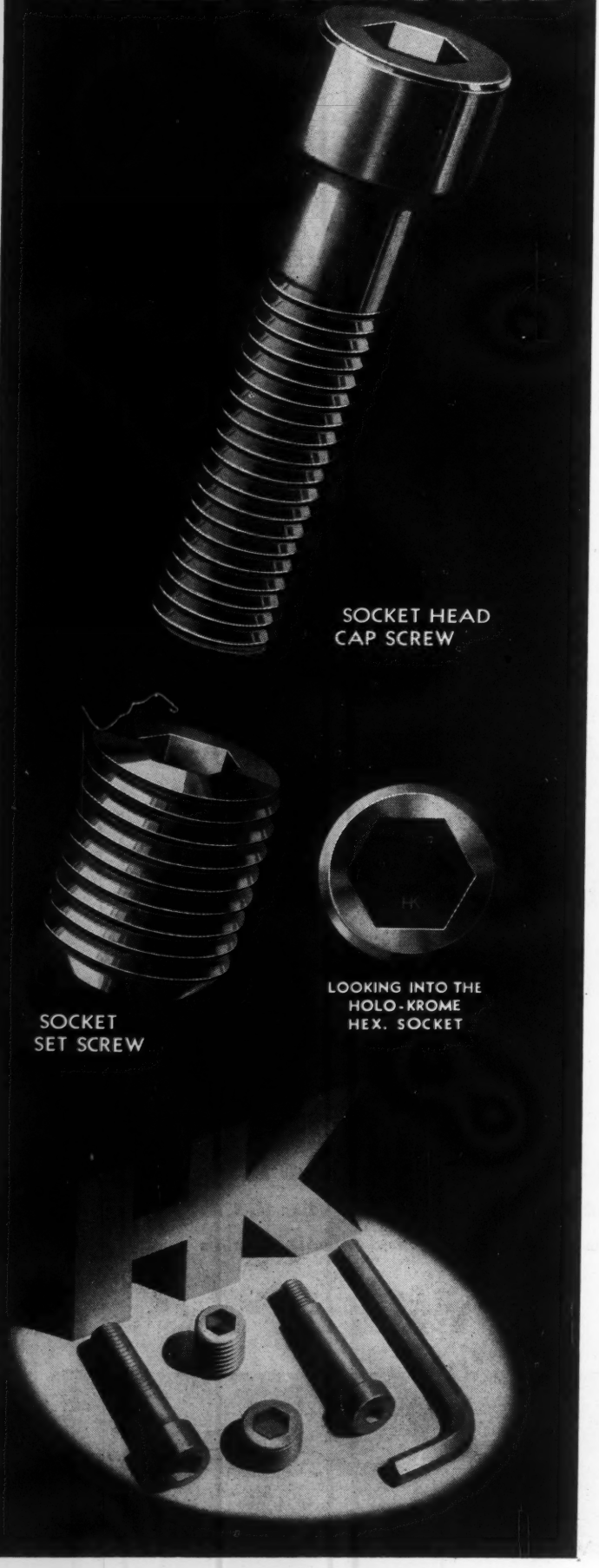
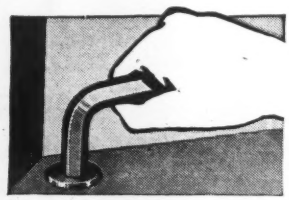
Sole Agent in England: Wm. Coulthard & Co. Ltd., Carlisle

HOLO-KROME



IN TOMORROW'S BLUEPRINTS Too!

Design and Production Engineers, in addition to their war-time activities, find time to blueprint future plans in preparation for the day they can be put into production. Machines and parts which will be required to sustain unusual stresses and vibrations must have their component parts securely fastened. Now is the time to investigate—prepare for tomorrow's production today!



INTERNAL WRENCHING FEATURE . QUICK & POSITIVE TIGHTENING

SOCKET SCREWS

The BETTER Fastening Method

Design and Production Engineers find the assistance given by Holo-Krome Fastening Engineers extremely valuable in planning their production schedules. Holo-Krome FIBRO FORGED Socket Screws, Completely Cold Forged by the Holo-Krome patented method, do the job for which they are intended with Guaranteed Unfailing Performance.

Catalog of Holo-Krome Products Gladly Sent

HOLO-KROME

fibro-forged SOCKET SCREWS

Manufactured Exclusively by

THE HOLO-KROME SCREW CORP.
HARTFORD 10, CONNECTICUT, U. S. A.

Cold Bending FASTER . . . MORE ACCURATE . . . AT LESS COST!

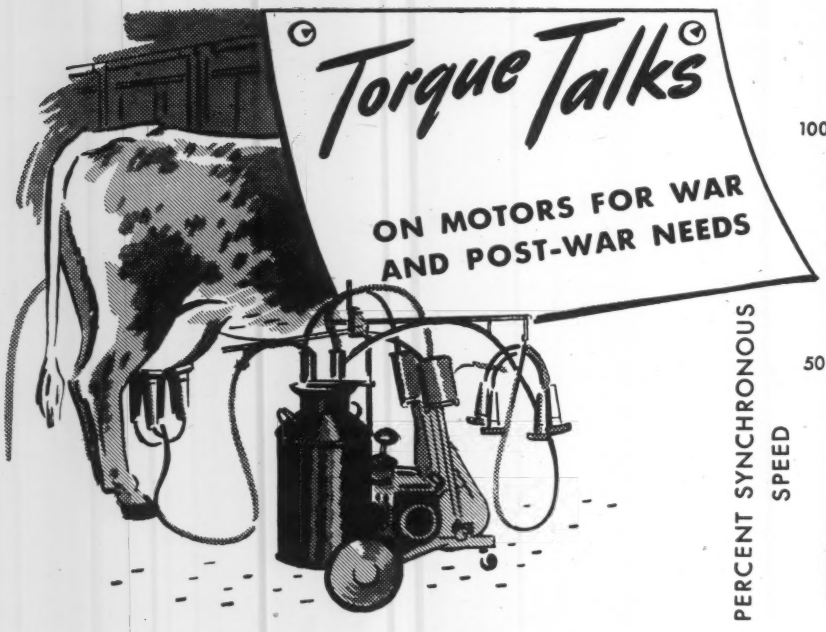
WALLACE BENDERS—HYDRAULIC, MOTOR-DRIVEN OR HAND-OPERATED—MEET EVERY BENDING NEED!

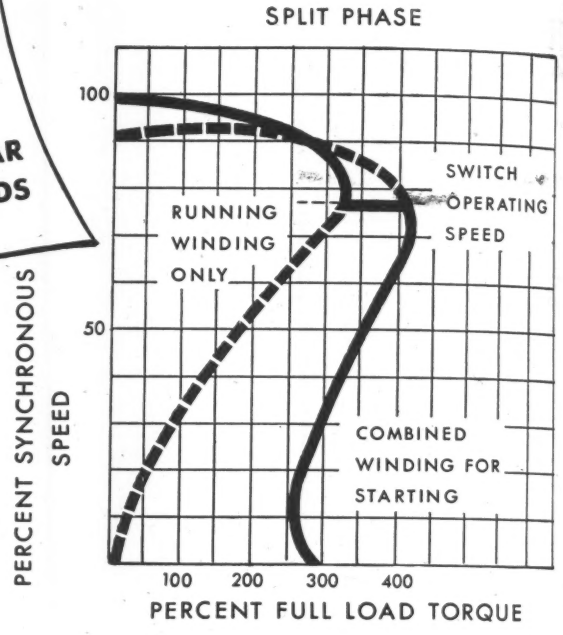
Cold bend to your exact specifications with a Wallace Bender . . . all ductile metals . . . tubing, solid bars, rolled moldings, extruded sections, structural shapes, pipe and conduit . . . at high-speed output for mass production of identical sections or at a custom rate where limited quantities of various bends are required . . . up to 16" diameter steel pipe or the equivalent in tubing or structural shapes.

Eighty-eight page manual-catalog giving complete details will be sent upon request.

WALLACE BENDING WSMCO SPECIALISTS BENDERS

WALLACE SUPPLIES MANUFACTURING COMPANY
1300 Diversey Parkway Chicago 14, Illinois





WHO'S GONE TO WAR

Imagine pedalling a grindstone, running a corn sheller or fanning mill . . . doing the milking, separating and cooling . . . pumping water, and countless other jobs on the farm . . . for wages of less than a cent an hour!

Yet that's exactly what the Type FHT motor will do for you on any farm job to which motor power can be applied. It's a high torque, split-phase motor . . . especially designed for continuous and intermittent duty applications where starting current over 20 amperes is permissible. Starting torque is from 200 to 250% . . . with 260 to 300% breakdown torque, in relation to running torque. It's the perfect solution for your worrisome farm problems.

ASK FOR APPLICATION HELP

For condensed information on this and other types of Westinghouse small motors, write today for The Westinghouse Small Motor Selector (Booklet 3075-A). It's a helpful aid to proper motor selection. Westinghouse Electric & Manufacturing Company, Dept. 7-N, East Pittsburgh, Pennsylvania. J-03197

PICK THIS MOTOR

- Where high starting and high breakdown torques are required.
- Where starting current over 20 amperes is permissible.
- Where starting is infrequent.

TYPE FHT HIGH TORQUE SPLIT-PHASE MOTOR

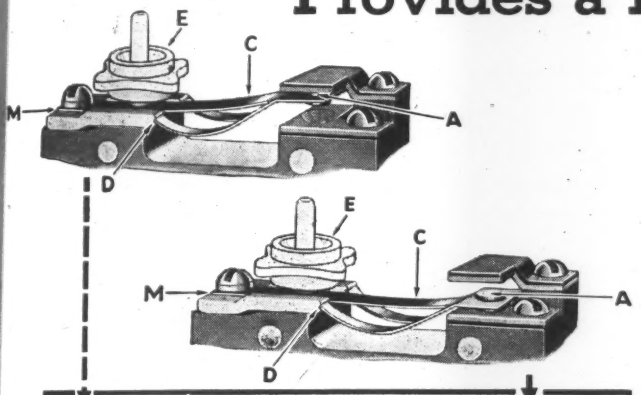
PHASE—Single
CYCLES—60, 50, 25
HORSEPOWER—⅙ to ⅓
VOLTS—110 or 220
SPEEDS—(Approximate full load)
60 cycles—1725
50, 25 cycles—1425

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Why MICRO SWITCH

Provides a Long Snap-Action Life



Micro Switch Operating Principle

The operating principle of the Micro Switch as illustrated here is simple and fundamentally correct. The long member of the one-piece spring "C" is supported as a cantilever at "M". The two shorter compression members of the spring rest in specially shaped (patented) V's. When the plunger "E" deforms the long tension member, the cantilever force overcomes the vertical force supplied by the compression members and the free end of the spring "A" snaps the contact from one stop to the other with lightning-fast speed. Snap action in the reverse direction occurs when the deformation of the tension members of the spring by plunger "E" is removed.

This one-piece beryllium copper spring is heat treated to provide the high fatigue resistance necessary to insure a minimum of 5,000,000 trouble-free mechanical operations, at full overtravel.

The rivet type contact is of superfine silver 99.95% pure.

The operating plunger is a highly polished, hard, stainless steel pin molded into an accurate Bakelite head. This head is so shaped that it cannot rotate, hence bears on the switch spring at the same point through millions of operations.

Micro Switch provides lightning-fast, snap-action control of electric circuits with reliable and positive operation accurately repeated over millions of cycles.

This performance is made possible by use of the unique, field tested, and proven operating principles of the Micro Switch. The snap motion of the Micro Switch contact is in the same direction as that of the operating plunger. There are no reverse bends in the Micro Switch spring, and there is no life-limiting "oil can" action.

The experience of design engineers with millions of Micro Switches in a great variety of applications has shown performance ability and operating characteristics never before found in snap-action switches.

Its small size, its high electrical rating, its ability to operate satisfactorily for millions of operations on minute movement and force differentials, its availability in various types of housings and a wide range of actuators . . . have made Micro Switch the choice of design engineers for precise operation of many types of plant equipment.

Micro Switch Handbook-Catalog No. 60 will give you complete details as to electrical characteristics, construction, applications and dimensions. If you happen to be specializing in aircraft equipment, also send for Handbook-Catalog No. 70.

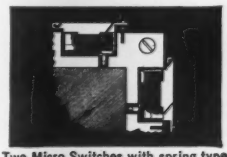
The basic Micro Switch is a thumb-size, feather-light, plastic enclosed, precision, snap-action switch, Underwriters' listed and rated at 1200 V. A., at 125 to 460 volts a-c. Capacity on d-c depends on load characteristics. Accurate repeat performance is experienced over millions of operations. Wide variety of basic switches and actuators meets requirements varying from high vibration resistance to sensitivity of operating force and motion as low as 2/1000 ounce-inches. Many types of metal housings are available.

© 1944

HUNDREDS OF SPOTS FOR MICRO SWITCHES

An explosion-proof Micro Switch is used with a spray gun to cut off the ventilating system of the spray booth automatically when the gun is hung up.

Micro Switches are used as safety switches on high tension cabinet doors. A normally open switch breaks circuit as door is opened.



Two Micro Switches with spring type plungers are used to insure correct position of material in jigs and fixtures.

Spring plunger Micro Switches serve as break indicators in textile and paper mills.

MICRO TRADE MS MARK SWITCH

A DIVISION OF FIRST INDUSTRIAL CORPORATION

FREEPORT, ILL., U.S.A., Sales Offices in New York, Chicago, Cleveland, Los Angeles, Boston, Dallas, Portland, (Ore.)

. . . . USES

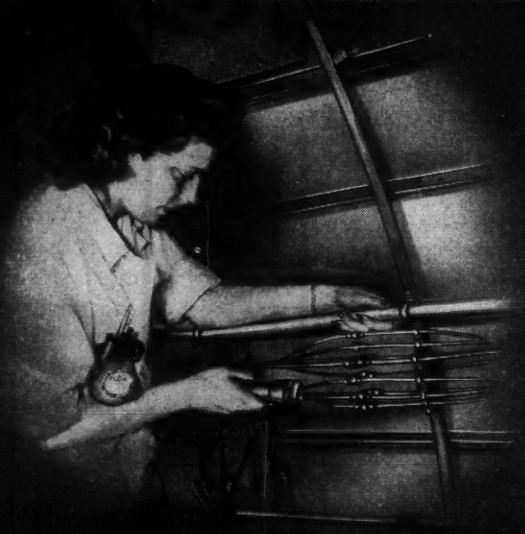
UNLIMITED

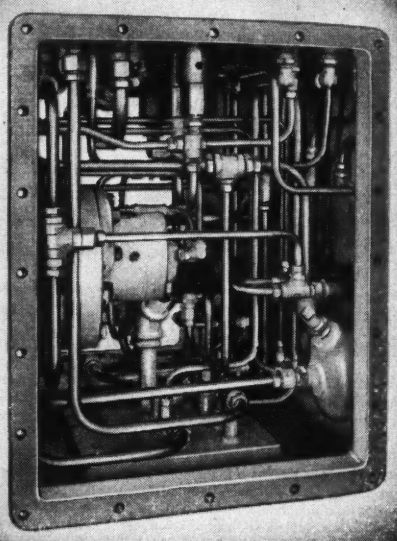
"Uses Unlimited"—a dramatic talking motion picture of Micro Switches, in color, is available to industrial groups, training classes, schools and colleges, through Y.M.C.A. Motion Picture Bureau, New York, Chicago, San Francisco. Size: 16 mm. Length: 40 minutes. Write us for details.

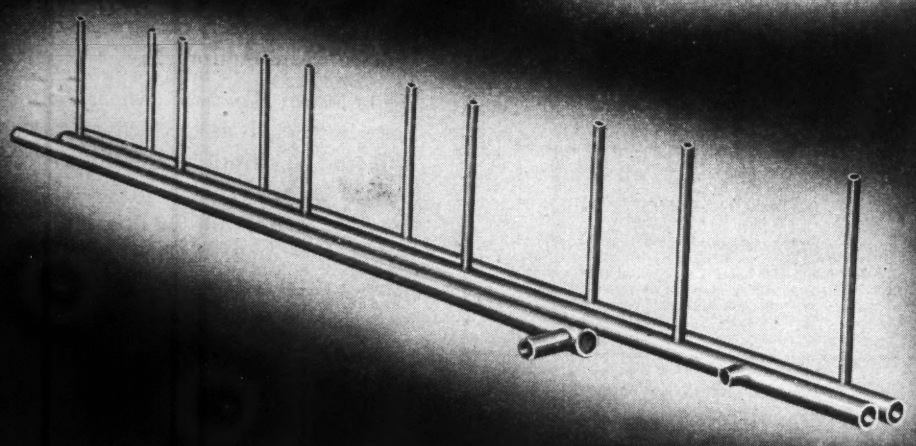
A star has been added to our "E" flag as further recognition to the men and women of Micro Switch for maintaining our war production standards.

Let's All Back the Attack—Buy Extra War Bonds

Seamless Steel Tubing . . .







provides strength for dependable pressure lines

Seamless steel tubing is being given wider and wider acceptance in industry as pressure, fuel and fluid lines. Engineers recognize the added strength embodied in solid steel walls. Other obvious advantages include light weight due to thin walls, freer passage of fluids, easier shaping and resistance to fatigue.

Today Michigan pressure tubing is playing a major role in America's war weapons and on the machines used to produce them. Tomorrow Michigan pressure tubing will fill a wide range of needs in peace-time industry. The many years of experience accumulated by Michigan Seamless Tube company are at your disposal.

AIRCRAFT • MECHANICAL • PRESSURE • STRUCTURAL

MICHIGAN TUBING

MICHIGAN SEAMLESS TUBE COMPANY

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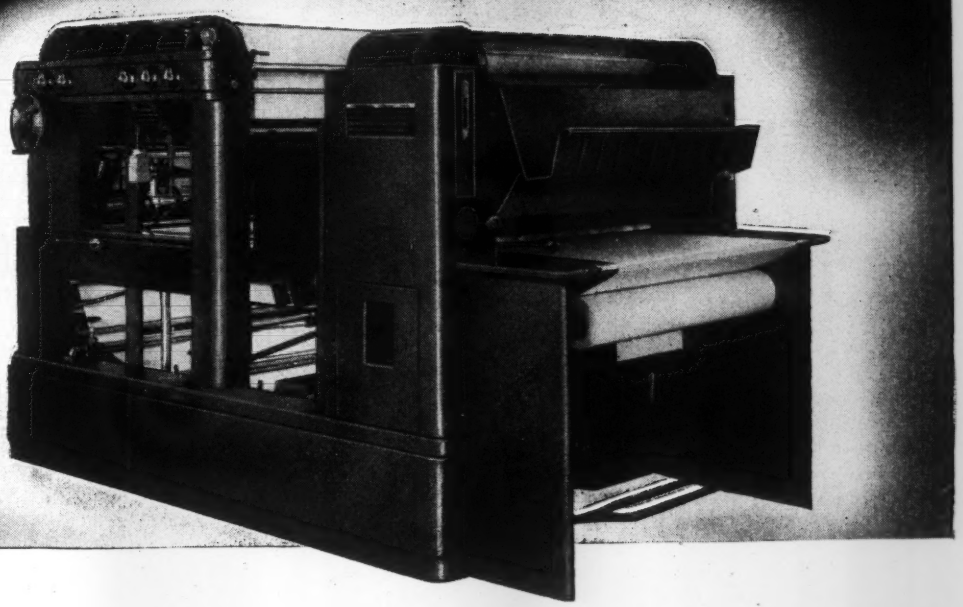
PUT YOUR RECONVERSION PLANS IN ACTION QUICKLY

WITH LOW COST *Blueprints*



...16" Continuous ... and Processing ... Developing and ... machine has an ac- ... production speed of 20 ... per minute.

Speed

Quality

Economy

RECONVERSION will not be a mere return to prewar production . . . The use of new materials and new methods will increase the demand for high quality Blueprints delivered quickly at low cost.

PEASE BLUEPRINTING MACHINES will provide these necessary Blueprints in volume and on time. Unparalleled in performance, fast and economical in operation, they require less attention and make sharper, clearer, more contrasty prints than any other tracing reproduction machine. Pease Blueprinting Machines are noted for their speed (Pease "22", not illustrated, produces prints at 30 feet per minute or more) and for their low cost, quality production . . . fine prints as low as one cent (or even less) per square foot.

PEASE SENSITIZED PAPERS, for use with any Blueprinting or Whiteprinting (Dry Direct Process) machines, are uniformly dependable for producing quality Blueprints, Blueline Prints, Brownprints (Negatives), Brownline Prints and Multazo Whiteprints.

Ask for descriptive literature and prices today.

THE C. F. PEASE COMPANY

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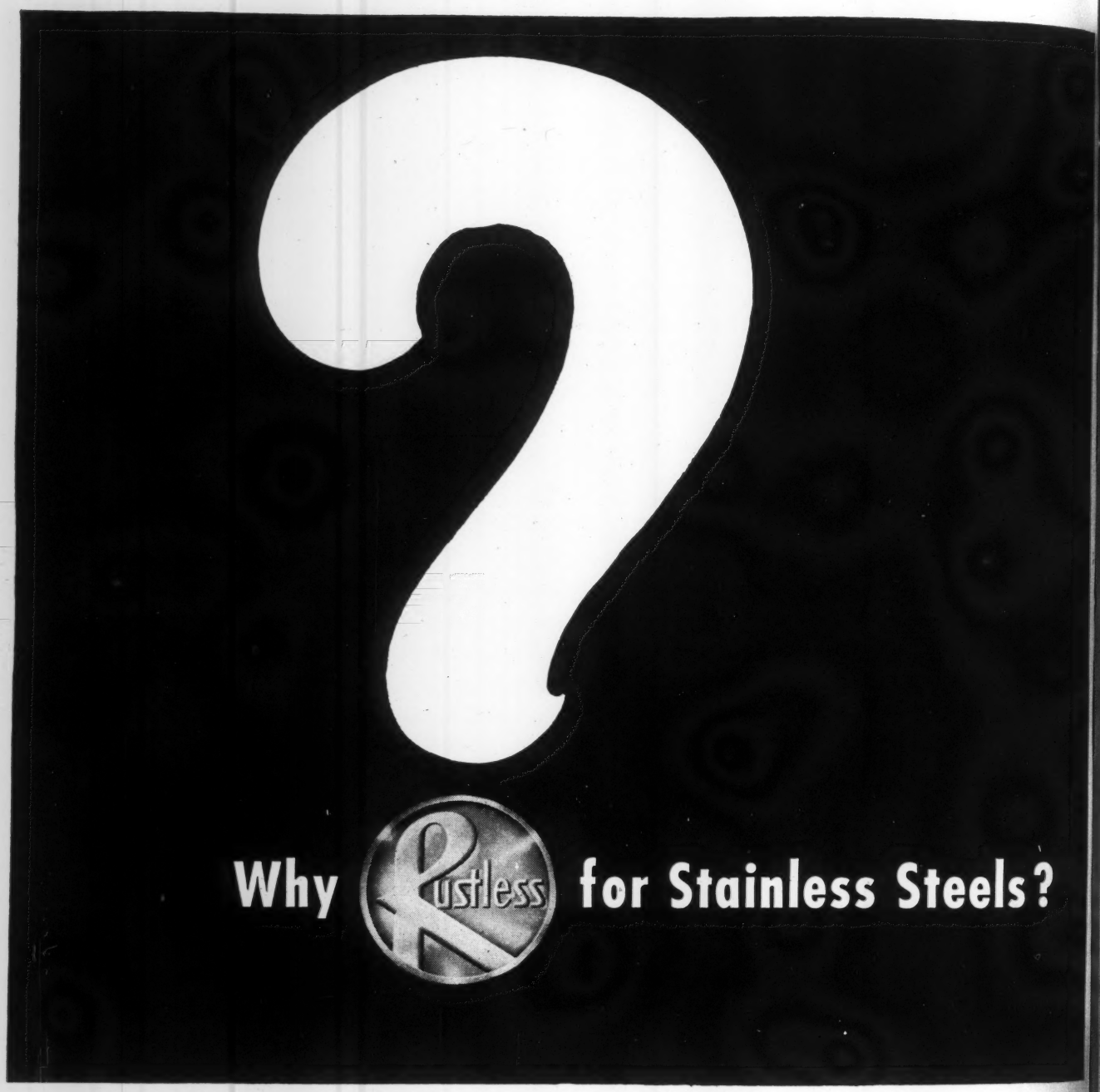
Pease Blueprinting Machines for all kinds of Tracing Reproductions



RUSTLESS has become one of the most important factors in the stainless steel industry.

One reason for this is that we specialize in the making of stainless steel, and experience has proved to American industry that it pays to deal with a specialist.

Our specialization has enabled us to work successfully with fabricators in solving manufacturing problems that involve machining, forging, cold working, welding, soldering, riveting, heat treating — or in selecting the proper type of stainless in order to obtain ease of fabrication and the economy of long, sometimes limitless life.

Your order, once you place it with us, is not just processed with standard alloy steel mill equipment. We employ many added engineering features that bring stainless steel into uniformly useful form.

Rustless makes stainless steels in over twenty grades readily available, and not only delivers billets, bars and wire, but provides detailed technical assistance with their fabrication. If you want to know more about stainless — ask Rustless.

RUSTLESS
IRON AND STEEL CORPORATION
BALTIMORE 13, MARYLAND
Producing STAINLESS STEELS *Exclusively*

SALES OFFICES: BALTIMORE
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They wanted TOY-SIZE fastenings able to withstand BIG-GUN CONCUSSION

¾" long, .037" dia.
140 threads to inch.

. . . and for these threaded "pin size" parts they chose a strong, corrosion-resistant INCO Nickel Alloy

The enemy isn't the only one to feel the shattering shock of a naval broadside. When the big guns thunder, everything aboard ship takes a beating.

Yet delicate vital instruments must function without a hitch. Every part . . . even the tiniest . . . must be able to withstand the tremendous concussion.

One such part in an essential instrument, is a fastening the size of a common pin . . . approximately ¾" long, .037" in diameter with 140 threads to the inch.

The metal chosen for this fastening needs:

corrosion-resistance, a necessity for sea-going equipment.
strength and toughness, to hold up under shock.
machinability, to permit speedy, economical machine production.

All of these requirements add up to "R" Monel . . . the corrosion-resistant alloy for parts where extra machinability is important.

* * *

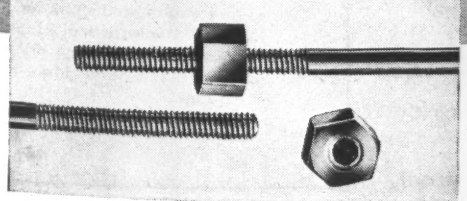
This use of "R" Monel is cited as an example of how INCO Nickel Alloys . . . such as "R" and "KR" Monel . . . often do the trick where a *unique combination* of properties is required.

If you have a problem involving metals . . . for equipment now in production, or planned for post-war . . . consult INCO Technical service. Write:

THE INTERNATIONAL NICKEL COMPANY, INC., 67 Wall Street, New York 5, N. Y.

Official U. S. Navy Photograph

140 THREADS TO THE INCH, *shown in this enlarged photograph, demonstrate the remarkable machinability of strong, corrosion-resistant "R" Monel. ("KR" Monel is suggested for applications where extra hardness is required.) The fastenings are machined from .037" diameter cold-drawn "R" Monel.*



INCO NICKEL ALLOYS

MONEL • "K" MONEL • "S" MONEL • "R" MONEL • "KR" MONEL • INCONEL • "Z" NICKEL • NICKEL
Sheet . . . Strip . . . Rod . . . Tubing . . . Wire . . . Castings

READY—IN 17 SECONDS

REPRODUCTIONS OF YOUR DRAFTSMEN'S DRAWINGS, TYPED MATERIAL, OFFICE FORMS

In this case, the operator is feeding a draftsman's pencil drawing, size 17" x 22", and a piece of sensitized paper into the machine. Smooth-running conveyor belts speed both materials around the printing cylinder . . . after which the drawing is automatically released, and the exposed paper goes up and across the dry-developing tank.

Here comes the Ozalid print . . . an exact duplicate—not a negative, of the original. You'll find it dry, ready for immediate use. And there's a very unique reason for the short time required—only 17 seconds . . . and for the fact that the print has black, or red, or blue lines on a white background—whichever color was desired.

WHY YOU MAKE PRINTS WITH THIS SPEED AND VERSATILITY

THE ANSWER is in OZALID DRY DEVELOPMENT . . . and what it has allowed designers and chemists to do.

Since only one developing operation is employed, the design of an Ozalid machine is extremely simplified. *So* compact in size you can install it in a corner of the drafting room or office. *So* easy to understand that any inexperienced person can quickly learn to turn out prints with maximum efficiency —using cut sheets or roll stock.

Also consider the amazing line of sensitized materials which react only to the *dry* principle . . . and offer this choice whenever you want to reproduce anything drawn, typed, printed, or photographed on translucent material:

• **Black, Red, Blue Line** standard papers which allow you to assign identifying colors to prints of different departments, to distinguish checked from unchecked prints, etc.

• **Transparent Papers, Cloths, Foils** which you use to produce Intermediate Originals and Composite Prints or to reclaim worn or soiled drawings.

• **Opaque Cloths** which give you prints of exceptional durability.

• ***NEW* Dryphoto Papers** which produce beautiful reproductions with all the halftone details, from photographic film-positives or perspective drawings.

See all of these Ozalid Prints yourself—and learn the complete story.

Write for "Simplified Printmaking" today.

ARMY E NAVY

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General Aniline and Film Corporation
Johnson City, New York

Ozalid in Canada—
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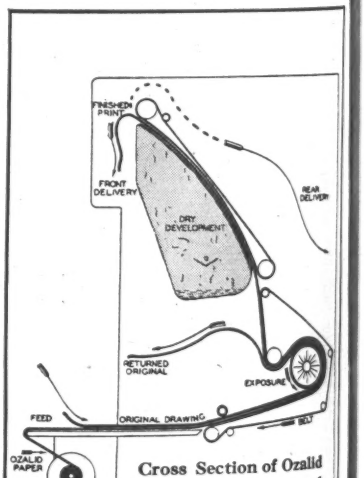
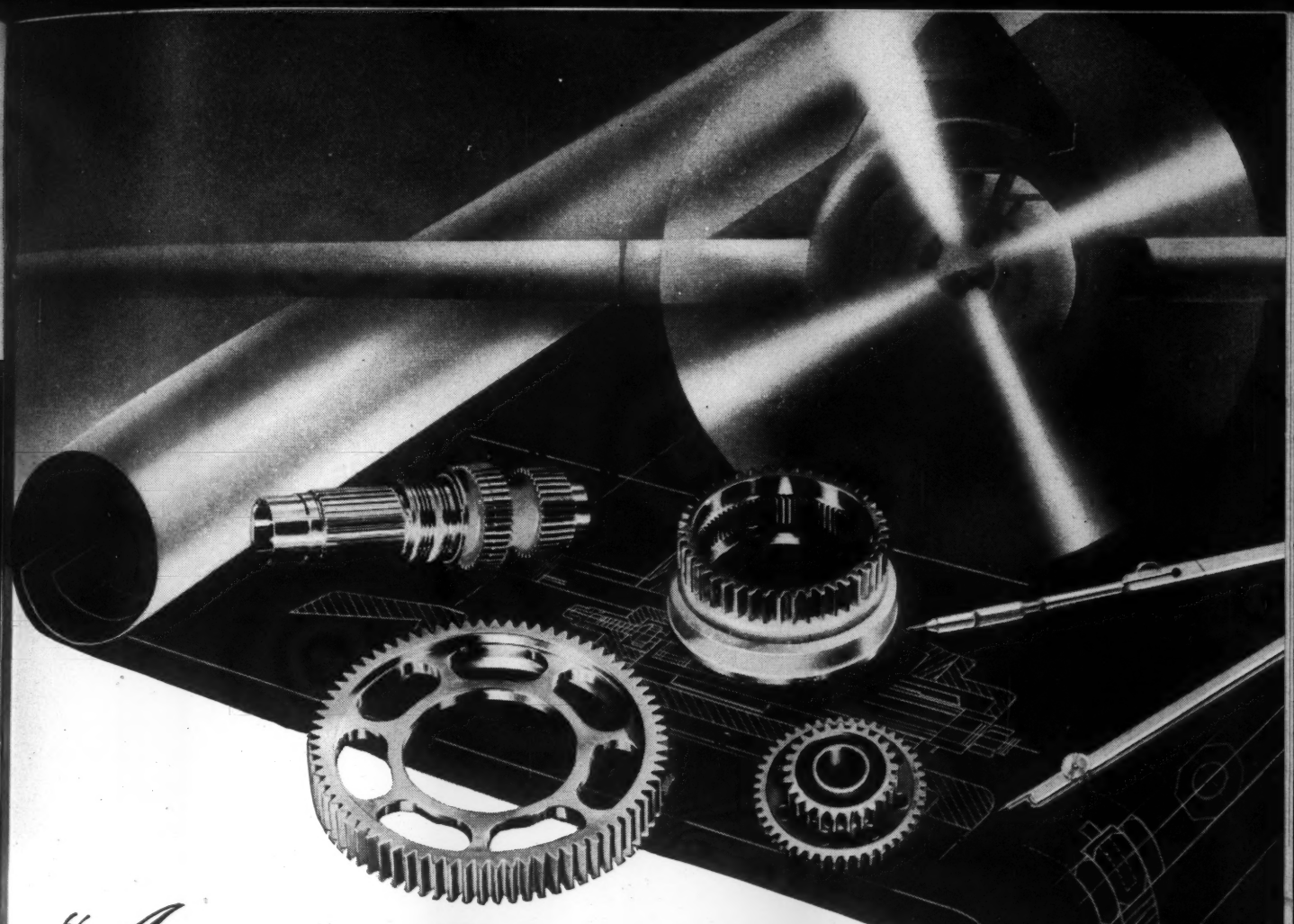


Cross Section of Ozalid Model B Illustrated Above. Designed for Large Scale Production. Other machines for lighter production or for use with blueprint equipment. Same *dry* principle, same advantages.



"Aircraft Quality" GEARS

OFFER ADVANTAGES FOR YOUR PRODUCT

War urgency demands the seemingly impossible of men and machines. Before the war the "aircraft quality" gears that Foote Bros. are today producing were hardly more than an engineer's ideal.

Today these gears, closely approaching theoretical perfection, are flowing off Foote Bros.' production line by the hundreds of thousands.

"Aircraft quality" gears were developed to meet the exacting demands of the powerful Pratt & Whitney engines. Light weight and tremendous strength—the ability to stand high speeds and heavy loads, and yet assure long life were essential. Despite extremely thin sections, "aircraft quality" gears must carry tooth loads far in excess of values customarily considered safe design and must operate at pitch line velocities that can be measured in miles per minute.

These unique qualities of Foote Bros. "aircraft quality" gears offer many advantages to manufacturers of equipment requiring the transmission of power. Right now in the drafting room and experimental laboratories of many of these manufacturers—designs for tomorrow's peacetime machines are being developed—new machines whose performance will be improved by the Foote Bros. gears incorporated in their design.

"Aircraft quality" gears may solve problems for your engineers—they will assure higher speed, longer life, lighter weight, more compact design—they may even make possible new developments that otherwise would be impractical.

To aid your engineers in determining the advantages which "aircraft quality" gears will bring to your product, our engineering department is now developing an engineering manual which should be in the hands of every designing engineer—every production man—facing problems of power transmission. A copy will be sent on request as soon as it is ready.

* * *

FOOTE BROS. GEAR AND MACHINE CORPORATION
Dept. O, 5225 S. Western Blvd. • Chicago 9, Illinois

This informative product engineering manual on "aircraft quality" gears contains data on a new and revolutionary type of precision gear. A copy will be sent to you on request as soon as it is ready.

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
5225 S. Western Blvd., Chicago 9, Ill. Dept. O

Please send me a copy of the Engineering Bulletin on "Aircraft Quality" Gears as soon as it is available.

Name.....

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City.....*State*.....

This switch design required not only the characteristics of a laminated plastic, but also the desirability of molding it. Thus, the arc chamber is composed of four units of INSUROK . . . laminated and molded laminated, fibre faced. INSUROK was used because of its constant dielectric and physical characteristics; its resistance to corrosion and ability to withstand continuous hard usage.

How INSUROK helps a Bull Dog control arcs

By keeping the amount of oxygen necessary to support combustion out of the arcing chamber, the Bull Dog Vacu-Break Safety Switch eliminates destructive arcing—secures better rupturing performance, conductivity and safety.

The four INSUROK units in which the contacts "make" and "break" comprise a partitioned arc chamber. Because INSUROK Precision Plastics assure close fitting; because of their high strength and dielectric qualities, they protect and make an important contribution to the efficiency of this Vacu-Break Safety Switch.

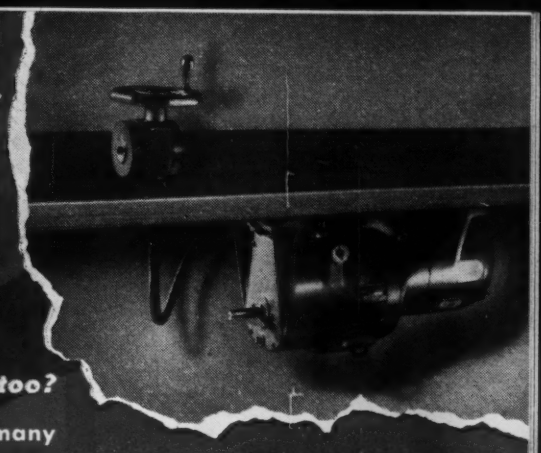
INSUROK Precision Plastics are available in a host of grades —in sheets, rods and tubes for fabrication in your own plant, or in completely finished molded or laminated parts or products. Perhaps it can solve one or more of your design problems, as it has thousands of others. For further information, consult Richardson Plasticians—without obligation, of course.

INSUROK

Precision Plastics

The RICHARDSON COMPANY

MELROSE PARK, ILL. NEW BRUNSWICK, N. J. FOUNDED 1868 INDIANAPOLIS 1, IND. LOCKLAND, CINCINNATI 15, OHIO
DETROIT OFFICE: 6-252 G. M. BUILDING, DETROIT 2, MICHIGAN NEW YORK OFFICE: 75 WEST STREET, NEW YORK 6, N. Y.



Why don't you get these* EXTRA *advantages too?

Variable speed operation offers tremendous advantages on many applications, and you'll find it's easy to secure even greater advantages . . . extra advantages from your variable speed drives when you use Master Speedrangers.

Extra advantages because the Speedranger is a compact integral unit . . . only one unit to mount . . . saves space, saves money.

Extra advantages because Speedrangers are available for every current specification, every type enclosure, with gearheads, unibrakes . . . and in the whole wide ranges of types in the Master line. This wide flexibility makes it easier to secure just the right drive for each installation.

Extra advantages because the all-metal construction of the Speedranger insures much longer trouble free service than can be expected of units where less durable materials are used.

Extra advantages because of the wide range of speeds . . . even up as high as 5000 R P M without the use of gearing.

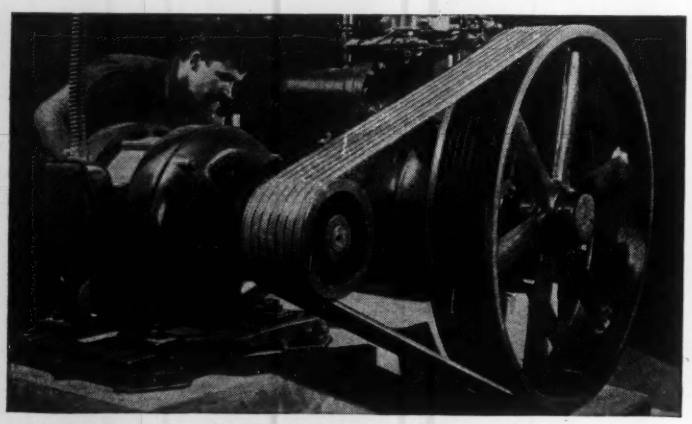
Extra advantages because Speedrangers are designed, built and guaranteed as a unit in one plant by one manufacturer. They are not an assembly of products . . . they're designed from the ground up as well balanced, integral units.

Investigate how easily YOU can secure the many extra advantages of variable speed operation by using Master Speedrangers.

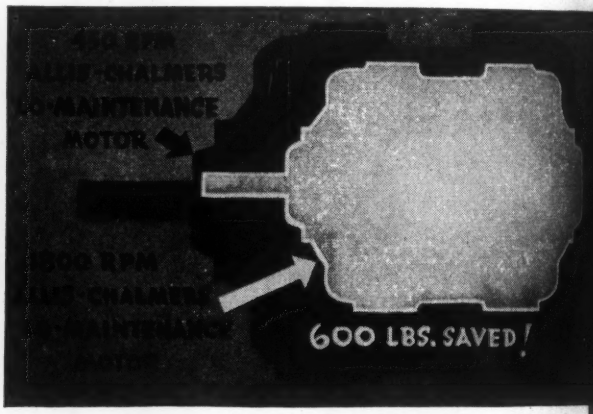
THE MASTER ELECTRIC COMPANY • DAYTON 1, OHIO

It's Time to
Look at Motor

➔*You Can Save with High-Speed Instead o*



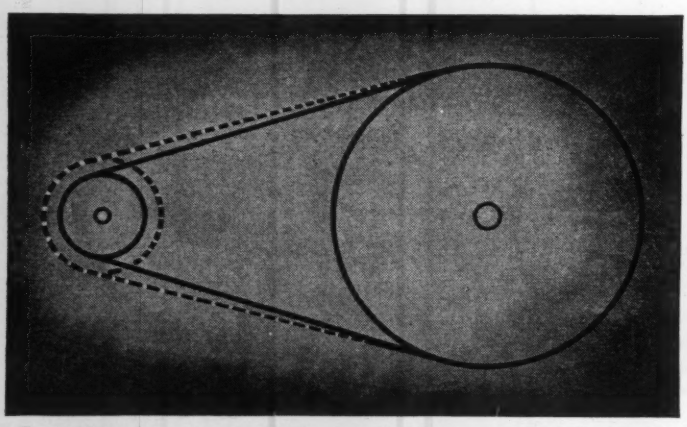
1. In most applications, an 1800 rpm motor with Texrope Drive will ably do the job of a lower-speed, direct-connected motor . . . *and* give you *exactly* the speed you want — *at lower cost!*



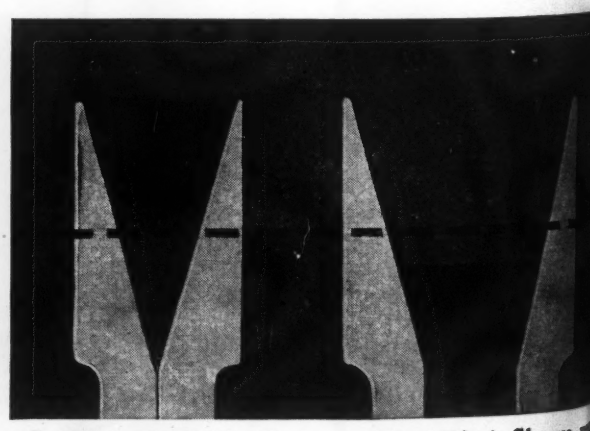
2. When you buy an 1800 rpm instead of 450 rp 15 hp squirrel-cage motor, for example, 600 lb critical materials are saved. And *you* save well ov $200—with the drive figured in! This saving is typic

3. No rpm m paring saves

➔*You Can Save with Single-Speed Instead o*



1. Infrequently needed speed changes can be had by changing from one size motor sheave to another. By juggling *complete* drives, speeds can be changed over the full range — from 1:1 to 7:1.



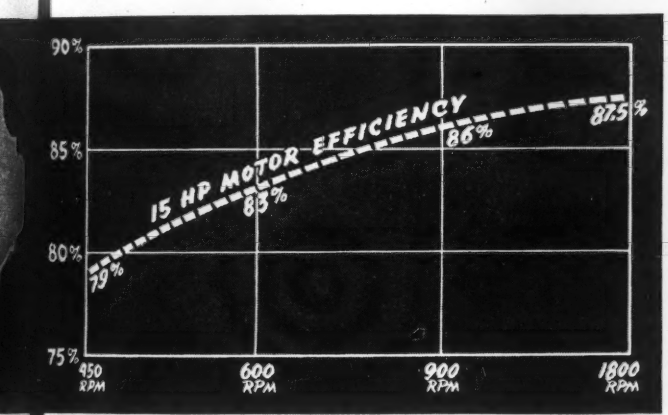
2. With the Allis-Chalmers Vari-Pitch Sheave, y can increase or decrease speed by adjusting shea diameter, as above. Within limits, an unbroke series of speeds can be obtained.

3. Alli you in 3.75 to speed

Take a Fresh Buying!

WAR FORCES HIGHER EFFICIENCIES...

Low-Speed Motors...



3. Note that efficiency rises from 79% for a 450 rpm motor to 87.5% for an 1800 rpm motor. Comparing power consumption, the 1800 rpm motor saves you over 30 kwh/24 hr. day.

Multi-Speed Motors...

3. Allis-Chalmers Vari-Pitch Speed Changer gives you infinite changes at the turn of a wheel — within 3.75 to 1. It's the most compact, flexible variable-speed transmission available.

It was good business in peacetime to use — as widely as possible — high-speed motors with Allis-Chalmers Texrope Drives... and single-speed motors with Allis-Chalmers Vari-Pitch Sheaves and Speed-Changers. And it's clearer every day that those material and money-saving practices are *vital* practices in time of war!

TODAY the whole picture of buying and applying motors has changed. Note at the left how much you can save for your country *and yourself* with high and single-speed motors made flexible by Texrope Drives.

As America's only builder of both electric motors and V-belt drives, Allis-Chalmers has long advocated the proper combining of motor and V-belt drive.

And today you benefit from Allis-Chalmers' vast, pioneering experience in this field when you ask for and get the *right* combination of Lo-Maintenance Motor and Texrope Drive! Call your nearby district office. Or write ALLIS-CHALMERS MFG. CO. MILWAUKEE, WISCONSIN.

A 1560

♪ *Tune in the Boston Symphony, Blue Network, Saturday at 8:30 pm, EWT.*

ALLIS-CHALMERS A-C MILWAUKEE

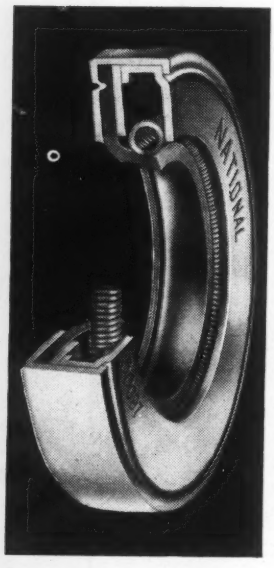
WE WORK FOR VICTORY WE PLAN FOR PEACE

Sealed~~~

● **Sealed orders** to safeguard the lives of men . . . men who have risked their lives in every age; in peace as in war; in their devotion to the progress of their fellow men.

Sealed Oil to safeguard the lives of men . . . to make possible speed. Speed on land and in the air; on the production line of giant industrial plants. Speed with the reassurance of safety.

National Oil Seals to keep that oil where it must stay for the safety of those men. Oil Seals . . . the answer to oil retention in modern machines . . . manufactured in the world's largest plants devoted exclusively to this job . . . the job of keeping oil in contact with the vital bearings that make possible the mechanical achievements of our day.



NATIONAL
OIL AND FLUID SEALS

Wherever shafts move

NATIONAL MOTOR BEARING CO., INC.
General Offices: Redwood City, California
Plants: Redwood City, California • Van Wert, Ohio

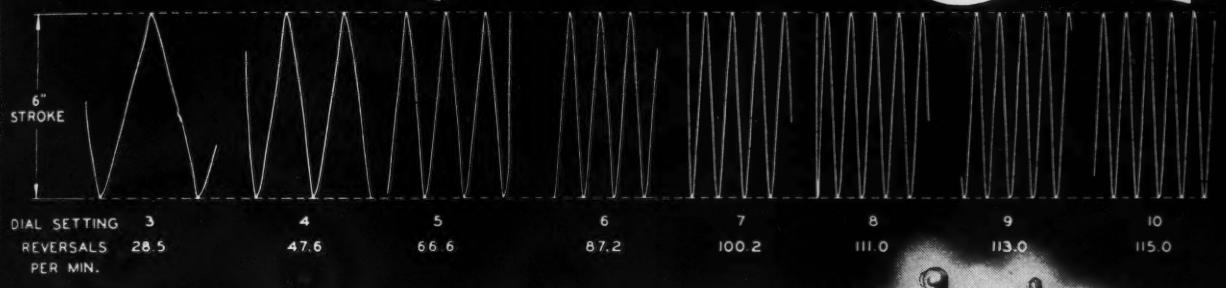
944

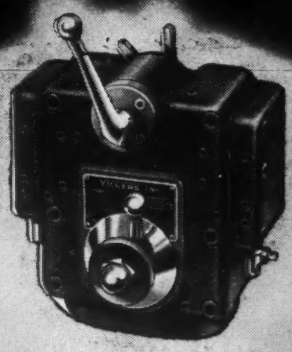
For Machines Requiring Continuous Reciprocating Cycles:

OVERRIDE PRACTICALLY ELIMINATED

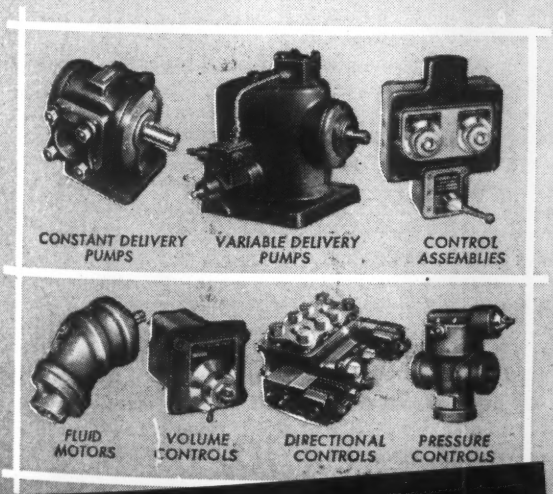
SMOOTH REVERSALS AT ALL SPEEDS

Note Uniform Length of Stroke





VICKERS "RECIPROCATING CYCLE" CONTROL PANELS



Representative of More Than 5,000 Standardized Vickers Units for Every Hydraulic Power and Control Function

This is a complete self-contained control unit for grinding machines, honing machines, or any process requiring a continuous reciprocating cycle.

The curves reproduced above were accurately made by a stylus attached to a reciprocating head and tracing upon a recording mechanism. Note uniform stroke length regardless of large changes in head or table speed. Throughout the test the setting of reversing trip dogs remained unchanged. An integral Vickers Hydrostatic Compensator makes flow rate (and therefore rate of reciprocation) independent of variations in resistance encountered. Similar tests and many installations show that at other speeds, loads and stroke lengths the same smooth reversals and accurate stroke length control are maintained.

Vickers Application Engineers will gladly discuss with you how "hydraulics" can be used to your advantage.

VICKERS Incorporated

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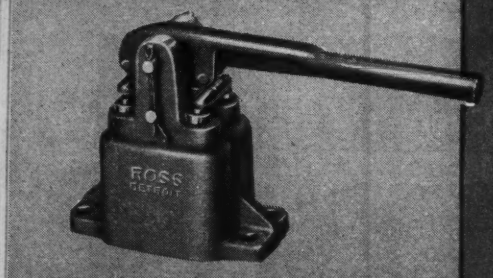
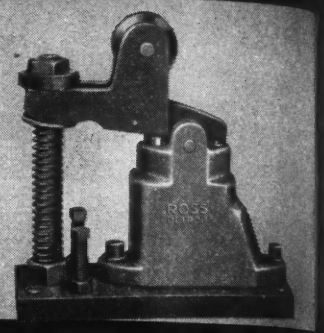
Application Engineering Offices: CHICAGO • CLEVELAND • DETROIT • LOS ANGELES NEWARK • PHILADELPHIA • ROCHESTER • ROCKFORD • TULSA • WORCESTER

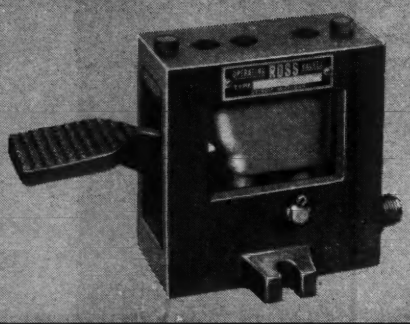


HAND CONTROL

96 STANDARD types and Sizes AIR CONTROL VALVES



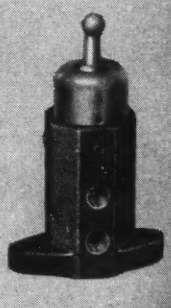
MECHANICAL CONTROL



FOOT CONTROL

ALL AIR CONTROL

SOLENOID CONTROL



PILOT CONTROL

Ross builds 96 standard types and sizes of air control valves. In most cases one of these will exactly meet your requirements—when, however, unusual demands call for a special design, then we engineer a valve to most efficiently fit your needs.

Representatives in Principal Centers

ROSS Operating VALVE CO.

6485 Epworth Blvd. Detroit 10, Mich.

ROSS Air Control VALVES

THE BRIDLE FOR AIR HORSEPOWER

Just to give you an idea . . .

. . . HOW AMERICAN INDUSTRY IS IMPROVING THE PERFORMANCE OF ITS PRODUCTS BY EFFECTIVELY USING KENNAMETAL'S UNIQUE WEAR RESISTANT PROPERTIES—DIMENSIONAL STABILITY, LOW COEFFICIENT OF FRICTION, AND EXTREME RESISTANCE TO ABRASION, CORROSION, EROSION, AND OXIDATION BY ELECTRIC ARCS.

These typical applications are shown to suggest how *you* may employ Kennametal—the metal that masters wear—at critical points in *your* products and production machinery. Kennametal is available in a variety of standard shapes, and it can be accurately molded into many special forms. Particulars are yours for the asking.

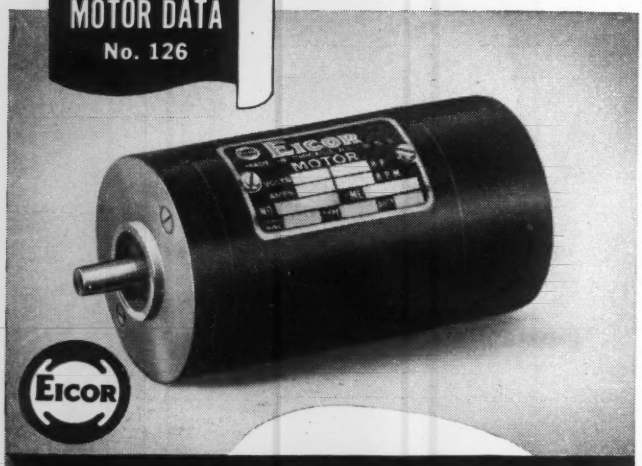
KENNAMETAL

SUPERIOR CEMENTED CARBIDES

TRADEMARK REG. U. S. PAT. OFF.

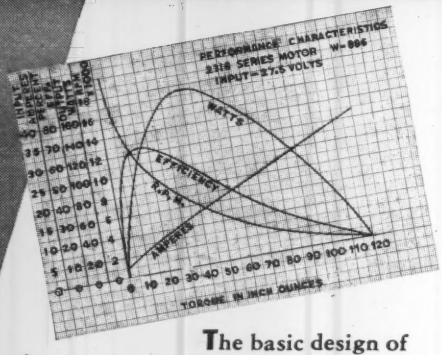
KENNAMETAL *Inc.*, LATROBE, PA.

MOTOR DATA
No. 126



EICOR

2300 FRAME MOTOR
1/5 HP at 3800 RPM



The basic design of the 2300 Frame Motor has been used in scores of individual modifications. Many of these designs are complete and available—others for new equipment can readily be developed.

FEATURES

ELECTRICAL

Series or shunt wound
High starting torque
Low starting current
High efficiency
Low RF interference
Unidirectional or reversible
Armature and field windings varnish impregnated and baked

MECHANICAL

Low weight factor
Unusual compactness
Completely enclosed
Base or flange mounting
Laminated field poles
Precision ball bearings
Segment-built commutator
Permanent end play adjustment

2300 FRAME MOTORS		2318 Series	2310 Shunt
Watts Output, Int.	(max.)	160	50
Torque at 6000 RPM	(in. oz.)	40	10
Torque at 3800 RPM	(in. oz.)	57	—
Lock Torque	(in. oz.)	120	14
Volts Input	(min.)	5	5
Volts Input	(max.)	110	28
Temperature Rise	(int.)	50°C	50°C
Diameter		2 5/16"	2 5/16"
Length less shaft		4 5/32"	2 3/4"
Shaft Dia.	(max.)	.312"	.312"
Weight	(lbs.)	2.4	1.5

EICOR INC. 1501 W. Congress St., Chicago, U.S.A.
DYNAMOTORS • D. C. MOTORS • POWER PLANTS • CONVERTERS
Export: Ad Auriema, 89 Broad St., New York, U. S. A. Cable: Auriema, New York

NEW MACHINES—
And the Companies Behind Them

Air Conditioning

Air scrubber, J. O. Ross Engineering Corp., New York 17.

Self-contained air conditioning unit, Carrier Corp., Syracuse, N. Y.

Aircraft

Desludging and cleaning unit for oil coolers and engines, Pacific Automatic Div., Airplane Mfg. & Supply Corp., Glendale 3, Calif.

Armament

Automatic horizontal shell borer, Davis & Thompson Co., Milwaukee 14.

Automotive

Charger for truck batteries, General Electric Co., Bridgeport, Conn.

Cleaning

Three-stage metal parts washing tank, Phillips Mfg. Co., Chicago 45.

Diesel

Diesel engines for generator drives, Sterling Engine Co., Buffalo.

Finishing

Heavy-duty polishing lathe, Jones Engineering Co., Ellwood City, Pa.

Food

Fully-enclosed multilouvre dryer, Link-Belt Co., Chicago.

Industrial

Pneumatically powered impact wrench, Aro Equipment Corp., Bryan, O.

Bench-type optical projector, Portman Optical Co., New Rochelle, N. Y.

Demagnetizer and etcher, Frampton Electrical Equipment Co., Dayton 10.

Lubrication

Electric portable power grease gun, Alemite Div., Stewart-Warner Corp., Chicago.

Marine

Twin-screw diesel tug, The Cooper-Bessemer Corp., Mount Vernon, O.

Aboard-ship communication system, Executone Inc., New York 7.

Metalworking

Grinder, Norton Co., Worcester, Mass.

Bushing press, Watson-Stillman Co., Roselle, N. J.

*Gear shaving machine, National Broach & Machine Co., Detroit.

*Heavy-duty formed wheel gear grinder, The Gear Grinding Machine Co., Detroit.

Vertical, horizontal milling machine, Benchmaster Mfg. Co., Los Angeles 6.

*Bench-type press, Colonial Broach Co., Detroit.

Plastics

*Injection molding machine, The Hydraulic Press Mfg. Co., Mount Gilead, O.

Restaurant

Automatic electric fry kettle, Edison General Electric Appliance Co. Inc., Chicago.

Rubber

Four-roll double coating calender, Farrel-Birmingham Co., Inc., Ansonia, Conn.

Welding

Alternating-current electric welder, Hampton Electric Mfg Co., New Kensington, Pa.

Portable gun welder, Eisler Engineering Co., Newark, N. J.

*Illustrated on Pages 160-163.

Contact **KAYDON** *of Muskegon*

For Unusually Large, High Precision Bearings

BALL and ROLLER BEARINGS

Standard and Special

FROM 6" INSIDE DIAMETER TO 100" OUTSIDE DIAMETER
COMMERCIAL FINISH OR SUPER PRECISION

Spherical Roller Bearings
Radial Ball Bearings • Thrust Ball Bearings
Radial Roller Bearings • Thrust Roller Bearings
Taper Roller Bearings

Straight or Self-aligning . Extra Heavy Duty or Special Light Type

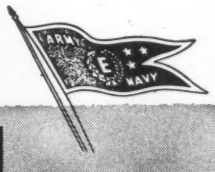
LIGHT WEIGHT NON-METALLIC CAGES OR STANDARD BRONZE TYPE

★ *Early Delivery* ★

PRECISION MACHINE WORK OR GRINDING

to unusual accuracy in large diameters

ATMOSPHERE HARDENING • FLAME HARDENING • PRECISION HEAT TREATING
METALLURGICAL LABORATORY • MICROSCOPY AND PHYSICAL TESTING



For excellence in production of extremely precise, unusually large ball and roller bearings

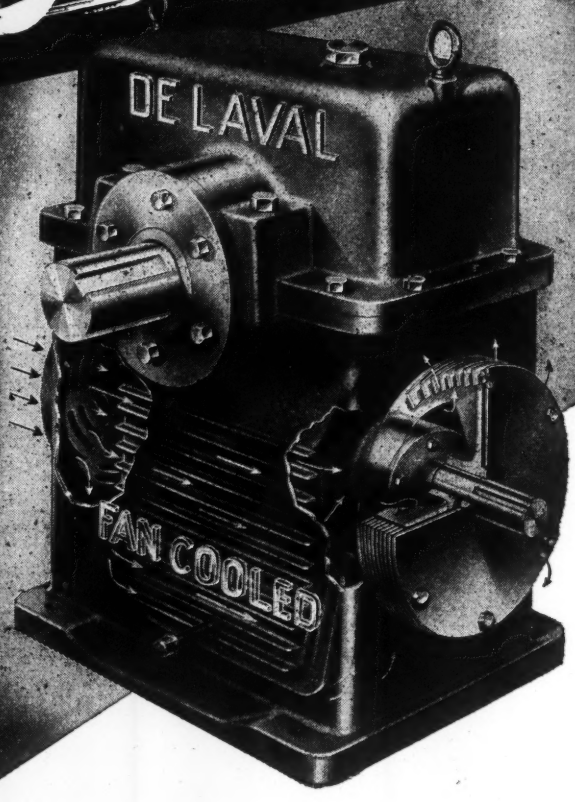
THE KAYDON ENGINEERING CORP.

McCRACKEN STREET • MUSKEGON, MICH.

New in Name . . . Old in Experience

SOON AVAILABLE

NEW FAN-COOLED



HIGHER CAPACITY

Capacity is approximately doubled for all ratios at 1750 r.p.m. as compared with standard heavy duty units of the same frame size.

LOWER COST PER HORSEPOWER

Operation at higher ratings permits the use of correspondingly smaller and less costly units.

SMALLER SIZE

Reduction of as much as two frame sizes in some instances. The use of smaller, lighter units results in a saving both of floor space and of critical materials needed for the war effort.

The *NEW* DE LAVAL *FAN-COOLED* WORM GEAR SPEED REDUCER

will soon be available in a complete line of sizes. Send for literature now being prepared.

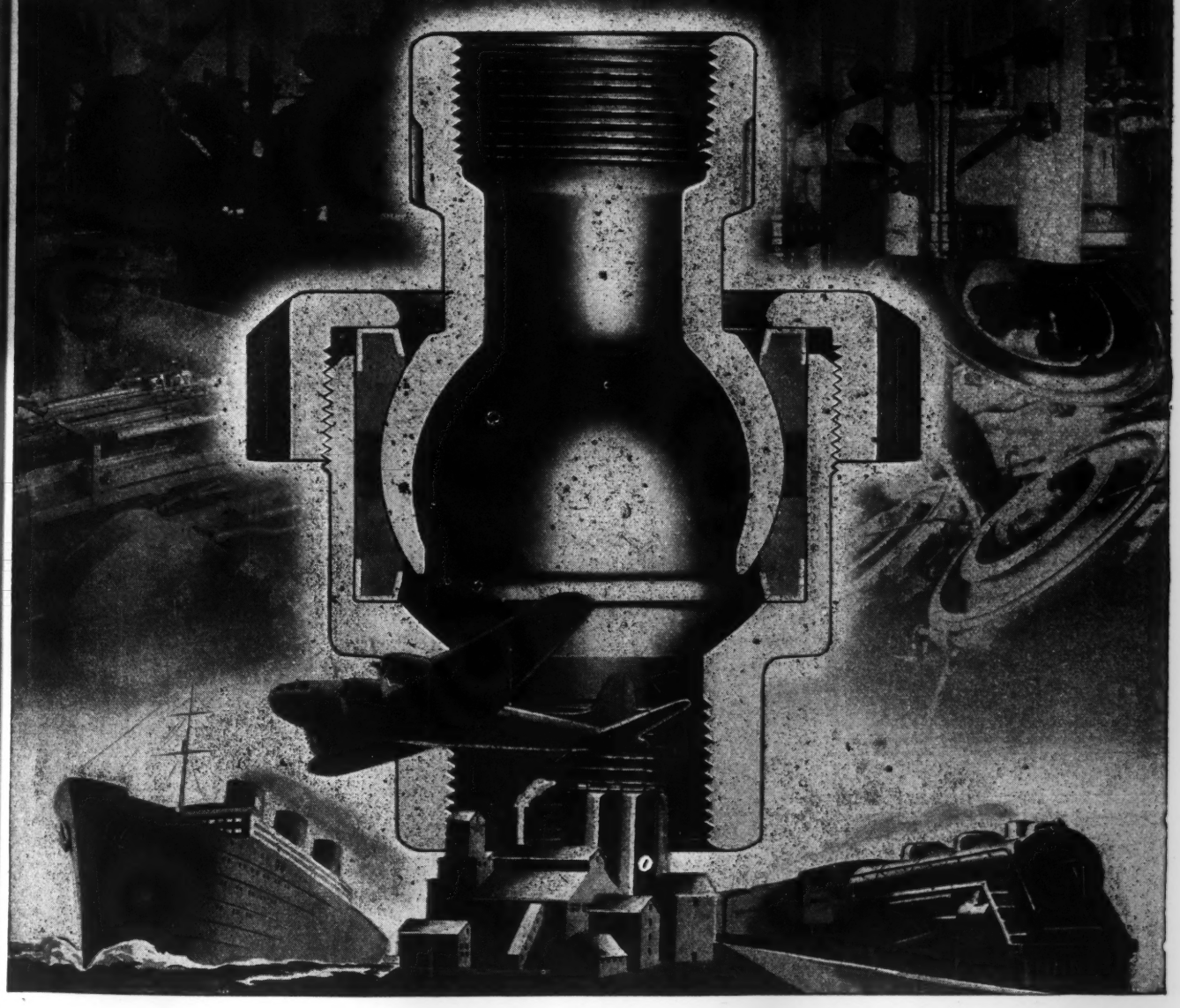
1149

TURBINES • HELICAL GEARS and WORM GEAR SPEED REDUCERS
CENTRIFUGAL PUMPS • CENTRIFUGAL BLOWERS and COMPRESSORS • IMO OIL PUMPS

WORM GEAR DIVISION
DE LAVAL
STEAM TURBINE COMPANY · TRENTON 2, NEW JERSEY

SALES OFFICES: ATLANTA • BOSTON • CHARLOTTE • CHICAGO • CLEVELAND • DENVER • DETROIT • DULUTH • EDMONTON • GREAT FALLS • HAVANA • HELENA • HOUSTON • KANSAS CITY • LOS ANGELES • MONTREAL • NEW ORLEANS • NEW YORK • PHILADELPHIA • PITTSBURGH • ROCHESTER • ST. PAUL • SALT LAKE CITY • SAN FRANCISCO • SEATTLE • TORONTO • TULSA • VANCOUVER • WASHINGTON, D. C. • WINNIPEG

Vital Links for Industry



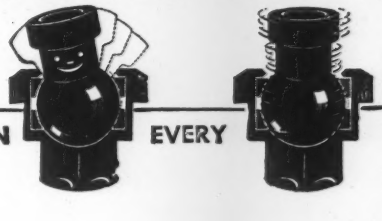
Fluid-conveying pipes carry the life-blood of industry and transportation. Vital links in these conveyor systems are Barco Flexible Joints—enemies of vibration and shock. Providing responsive movement through every angle, Barco compensates for all stress and strain, expansion and contraction. Over 30 years' experience in solving flexible joint problems is yours when you consult Barco's engineering department.

In Canada: The Holden Co., Ltd., Montreal, Canada

BARCO **FLEXIBLE JOINTS**

MANUFACTURING CO., NOT INC. • 1806 Winnemac Ave., CHICAGO 40, ILL.

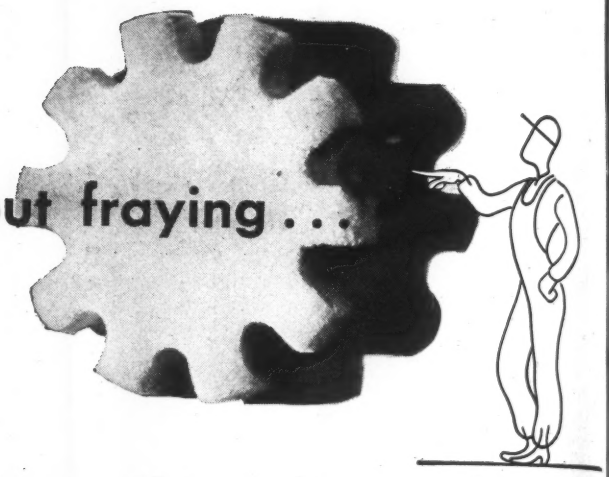
Not just a swivel joint...but a combination of a swivel and ball joint with rotary motion and responsive movement through every angle.

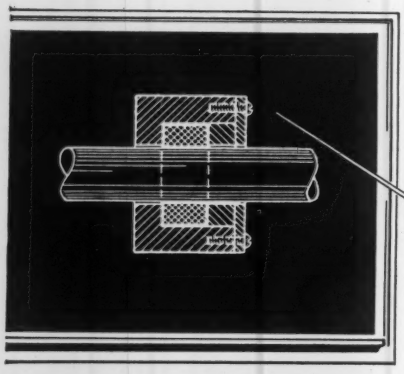


THE FREE ENTERPRISE SYSTEM IS THE SALVATION OF AMERICAN BUSINESS

"MOVE IN EVERY DIRECTION"

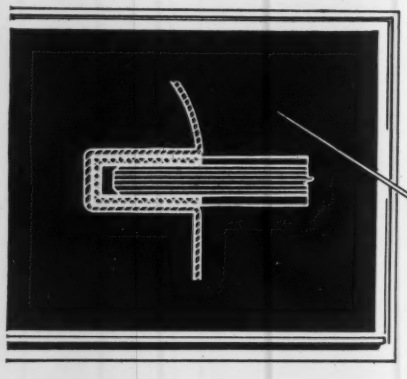
Felters Felt cuts without fraying . . .





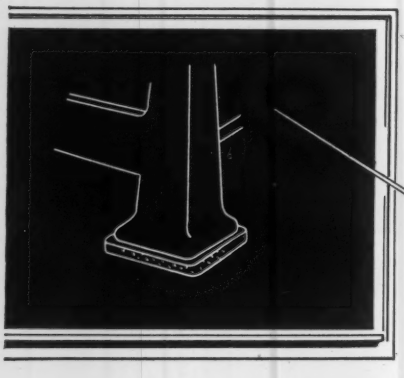
it keeps oil in & dirt out of bearings

Felt lubrication seals—like all Felters cut parts—are cu by our own men from our own designed dies. These lubrication seals are compressible for tight fit, grease absorbent for low friction. Made of hard, tough, fibrous structure for long life.



it keeps the weather out

Because of its lasting resiliency, Felters felt conforms to irregularities, keeps joints tight, *locks out* noise and weather. Used as guides for bus windows, acoustical and thermal insulation for aircraft, and many other applications.



it makes soft-soled shoes for busy feet

Base pads to take the throb out of machine feet—by absorbing and dampening vibrations—can be cut to any shape desired. Felters wide range of consistencies and thicknesses assure proper cushioning for the application. For the complete story on felt cut parts, write for our booklet, "Felt as a Design Material". The Felters Company, 210 R South Street, Boston, Massachusetts.

_____ put in your post-war picture

BAKELITE

TRADE-MARK

Ideas are Ammunition, Too

This is the largest item ever molded from BAKELITE phenolic molding board, BM-9725. It's an ammunition box for a bomber belly turret that packs looped lightning in the form of long belts of cartridges. It is 25½ in. by 17½ in. by 6½ in. in size. It is extremely lightweight, highly resistant to impact, abrasion, moisture, and chemicals, and has high tensile strength.

Until now, the plastics industry has used BAKELITE phenolic molding board chiefly for much smaller parts. The idea of employing its outstanding advantages for a large scale molding job was revolutionary, but has more than justified itself in a product that stands strenuous service, and is economically produced. Rigidity and extra strength are attained by molding the box from two sheets of BM-9725 around a sisal core that has been impregnated with phenolic resin. Both halves of the box are formed simultaneously in one cast iron mold. The press is equipped with banks of infrared lamps for preheating the mold charge and operates at a pressure of 1,000 pounds per square inch.

Ideas such as those that produced this box are ammunition for present and future planning—ammunition that hits the mark in product improvement and production economy. BAKELITE molding boards are available in sheets, blanks, and as diced material. They can be molded on existing equipment—either alone, or in combination with other BAKELITE plastics to reinforce vital points. Write Department 11 for full information and suggestions regarding molding techniques

TRADE MARK

BAKELITE CORPORATION, 30 E. 42 St., New York 17, N. Y.

Unit of Union Carbide and Carbon Corporation

UCC

Molding Plastics

Quick CUT-OUTS in steel

save time, cost, materials in shaping metal parts

If you are planning products made of steel, it will pay you to consider these many advantages of MACHINE GAS CUTTING:

- **It provides almost unlimited freedom in cutting steel of any section into regular or irregular shapes.**
- **It requires no elaborate patterns—merely an actual-size tracing, or metal or wooden template of the shape to be cut.**
- **It offers notable economy and flexibility in steel cutting because of its speed and easy "changeover" from one cutting job to another.**
- **It permits most economical utilization of steel with minimum scrap loss. Nesting of parts, stack cutting, and multiple-torch cutting are some of the ways in which its fullest economy may be realized.**
- **Its accuracy effects considerable savings in machining time and cost, and often makes finish-machining unnecessary.**

In view of these important advantages, more and more design engineers are including machine gas cutting in their new product plans. Some indication of the wide range of shapes currently being produced is shown by the parts illustrated above and at the right.

If you want further details on the scope of machine gas cutting and the many new design freedoms it offers, representatives of Air Reduction's Field Engineering Division will supply full information. Write to Dept. MD, New York office, for further information.

BUY UNITED STATES WAR BONDS

AIRCO

AIR REDUCTION

General Offices: 60 EAST 42nd STREET, NEW YORK 17, N. Y.

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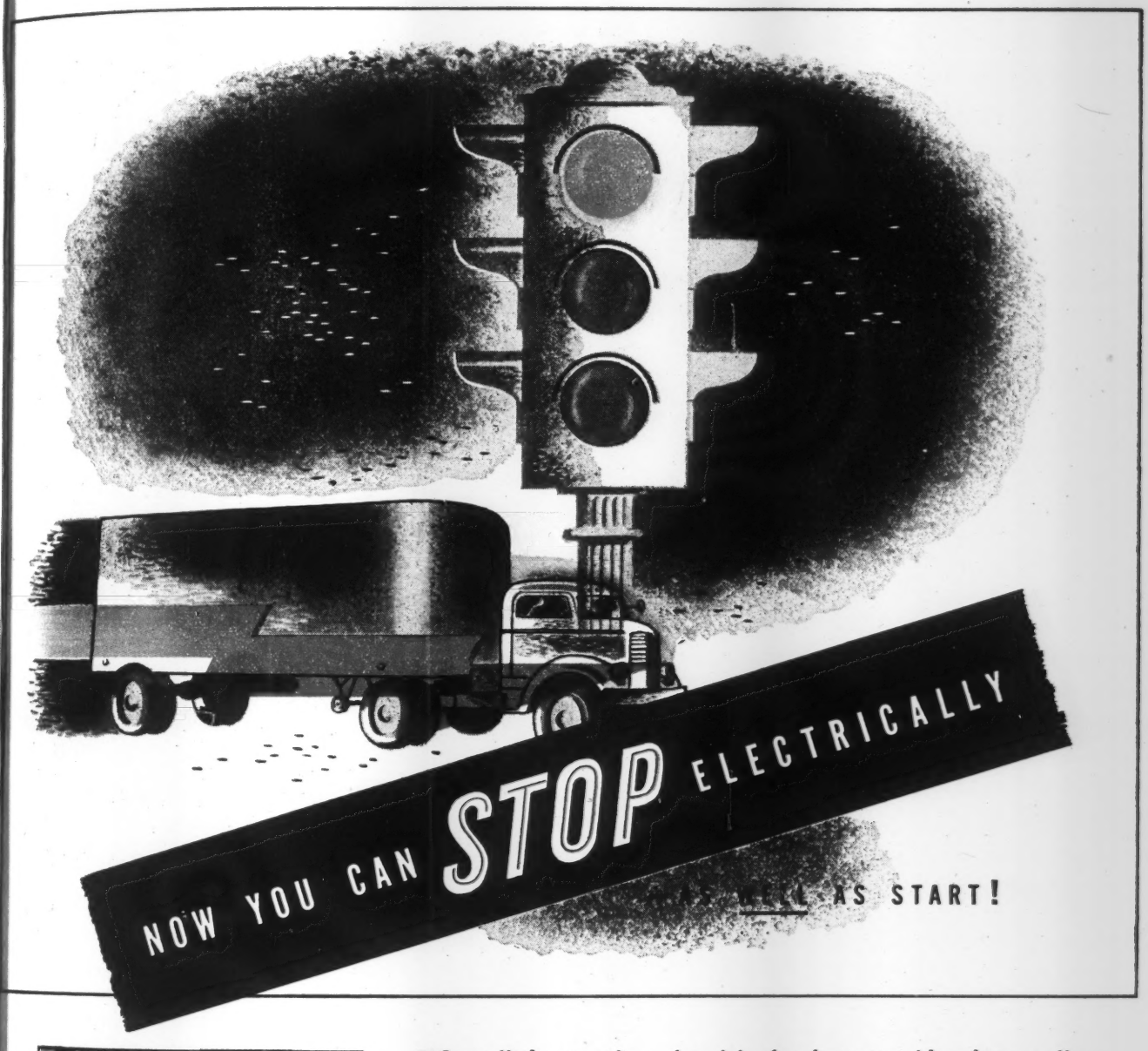
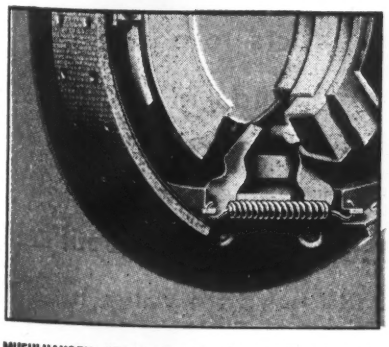




MUEHLHAUSEN SPRINGS PREVENT FROZEN BRAKES

AS applied to motion, electricity has been considered generally as a starting and moving force—but now, with Warner Electric Brakes, it is used for stopping as well.

This brake has another thing in common with many other products—the use of well-engineered springs to control important mechanical actions. Warner relies on Muehlhausen Springs to free the brake bands after the vehicle has slowed or stopped. On one grueling run after another, through heat, rain and crystallizing cold, Muehlhausen Springs perform this job automatically.

A big responsibility for a little spring! But, because of careful design by experienced engineers, it does its job unfailingly.

MUEHLHAUSEN SPRING CORPORATION *(Division of Standard Steel Spring Company)*, 525 Michigan Avenue, Logansport, Indiana

Leading product designers in every industry are consulting Muehlhausen Engineers to secure springs of lasting efficiency.

MUEHLHAUSEN
SPRINGS
MS
EVERY TYPE AND SIZE

Look to Fenn with Confidence

for ★ Special Machinery ★ Special Tools ★ Special Parts

AS designers and builders of special machinery, special tools, and special parts FENN brings you the accumulated experience of ***three generations*** continuously engaged in precision machine shop work.

FENN will handle the entire job from blue prints straight through to the finished machine, tool, or part; or take your idea, develop it, and build a machine that will do what you expect of it.

FENN'S long experience on the shop floor and their knowledge gained in solving many difficult mechanical problems give them an individual approach to every problem. For FENN definitely expects to add that something to the finished machine that will pay dividends in faster, smoother, more dependable operation.

IT costs nothing to consult with FENN and no obligation is incurred until you are certain that they can contribute tangible, measurable value to your machinery problems. Your inquiries will have careful and prompt attention.

THE FENN MANUFACTURING COMPANY

Hartford, Connecticut

Builders of Better Machinery To Meet New Demands

Ampco Extruded Hollow Rod

Saves Metal

Saves Machining

Saves Time and Money

Sizes closely parallel most requirements — saving time and material. Quality is high; Ampco Hollow Rod actually is replacing forged material in valve seats for aircraft engines — evidence of its clean, sound structure and excellent physical properties . . . This Ampco product is intended primarily for bushings, sleeves, leadscrew nuts, and similar machine parts. Write for new price list of Ampco extruded products.

Reg. U.S. Pat. Off.

AMPCO

— processed in Ampco's 2275-ton extrusion mill, one of the many facilities and services which make Ampco Metal, Inc. a complete, self-contained source of copper-base alloy parts.

TURN THE PAGE

Ampco Metal Parts made from extruded stock

All the inherent advantages of Ampco Metal—its exceptional resistance to wear, impact, fatigue, and corrosion—its specific properties as a series of engineered aluminum bronze alloys, held within close limits by rigid quality control — are available to you in all the forms by which metal is commonly worked. Ampco facilities include

Sand Casting	Annealing, Heat Treating
Centrifugal Casting	Precision Machining
Forging, Swaging, Rolling	Welding
Extrusion	Other Fabrication (spinning, bending, etc., etc.)

Ampco also offers you a specialized engineering and production "know-how" to convert your design into a practical manufacturing proposition. Ampco's nation-wide organization of field engineers is ready to assist you. Call on us. Write on your business letterhead for Engineering Data Sheet 125 and Ampco Metal Catalog.

Only from Ampco can you get *all* of these services and benefits *conveniently:*

1. Distinctive properties of resistance to wear, impact, fatigue, corrosion.
2. A series of engineered alloys — with physical properties to fit your application.
3. Quality control to hold these properties within narrow limits.
4. Diversified production facilities — coordinating in one place all the commonly used metalworking processes.
5. Engineering and production "know-how" to give you a practical manufacturing program.
6. A nation-wide organization of field engineers to assist you.
7. A record of proved performance in hundreds of leading makes of equipment.
8. A national reputation that makes Ampco Metal parts a sales asset.

. . . Specialists in engineering — production — finishing of copper-base alloy parts.

AMPCO Reg. U. S. Pat. Off.

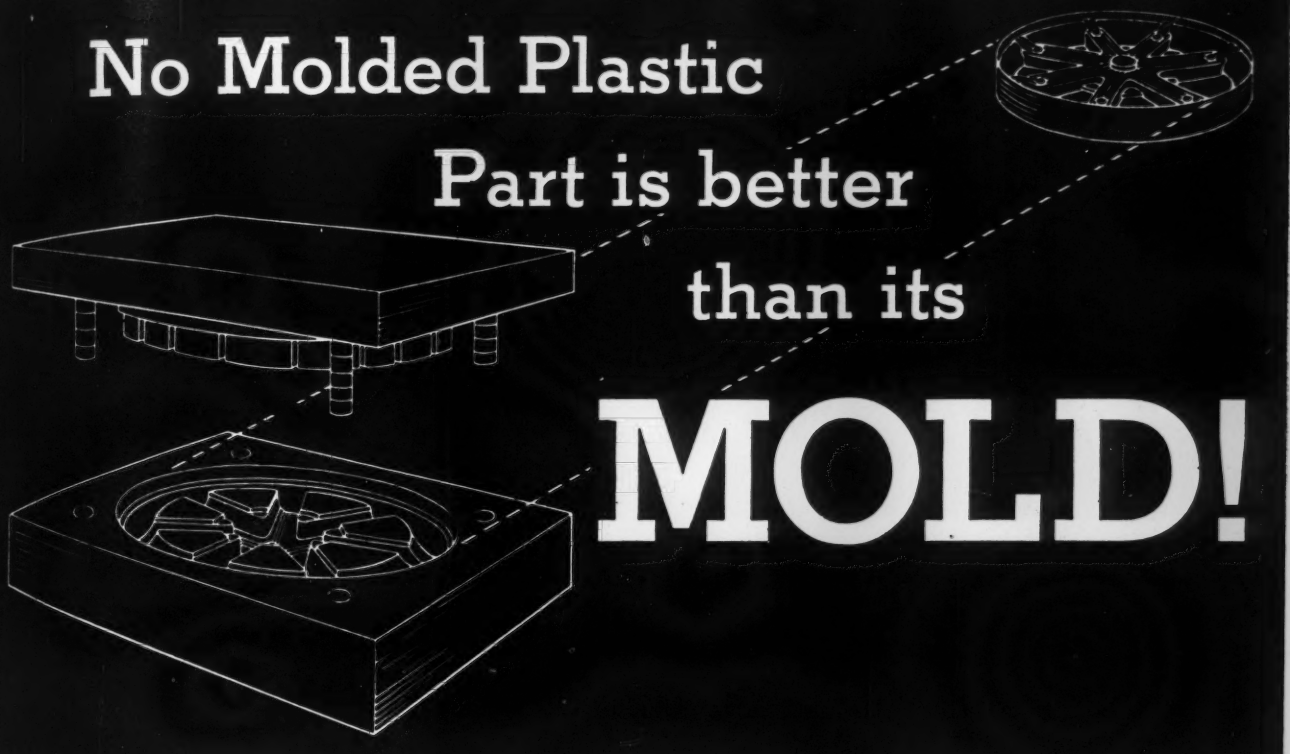
Metal

The Metal without an Equal

Ampco Metal, Inc.
Dept. MD-12
Milwaukee 4, Wis.

Ampco Field Offices in Principal Cities

No Molded Plastic Part is better than its MOLD!



THE MOLD is the master pattern which governs the shape, dimensional accuracy, and surface finish of every part that comes out of it. Likewise, the ingenuity with which it is designed often governs the speed and economy of production. It is the most important single factor in the process of plastic molding.

That's why we put so much emphasis on mold-making . . . why we are satisfied with nothing short of perfection . . . why we maintain one of the largest and best equipped mold-making departments in the industry, manned by highly skilled and experienced craftsmen.

We know mold-making . . . and we should, for the men who founded CMPC and are its directing heads today have been designers and builders of molds for a quarter of a century.

That's a good point to bear in mind when choosing your plastic molder. And, remember, too, that CMPC offers a complete service . . . designing, engineering, mold-making, molding, and finishing . . . backed by an organization with over 25 years of experience and the largest, best equipped custom molding plant in the Middle West.

We've been at it for over 25 years

You can get action on your postwar plans . . . NOW!

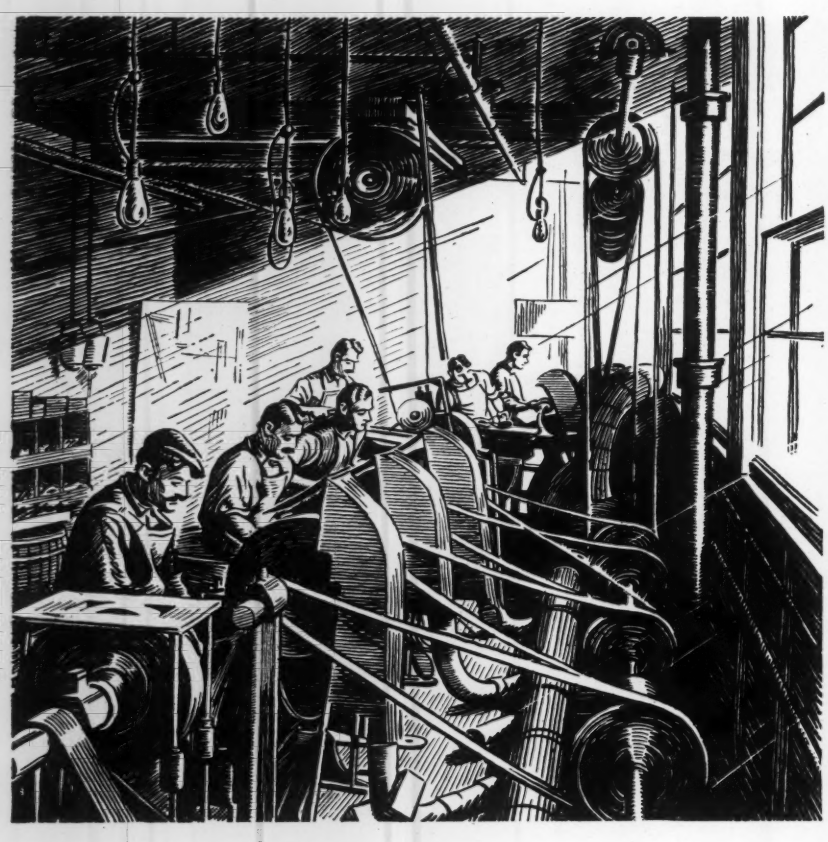
If you're thinking in terms of plastics for your post-war product, ask for the services of a CMPC Development Engineer. He can be of real help to you . . . by determining what parts can be advantageously molded of plastics . . . by helping in the selection of materials . . . by putting at your disposal the latest wartime developments . . . by suggesting design for most effective and economical results . . . by making laboratory tests, building experimental molds, or building your finished production molds.

This preliminary work can be done now. Then, when priorities are lifted you'll be in line for production as soon as materials and press capacity are available. Write today. There's no obligation.

CHICAGO MOLDED PRODUCTS CORPORATION

1028 N. Kolmar Ave. Chicago 51, Illinois

COMPRESSION, INJECTION, AND TRANSFER MOLDING OF ALL PLASTIC MATERIALS



BACKGROUND FOR KNOW-HOW

The telephone was still a novel device when *Connecticut Telephone & Electric* opened the doors of its first modest factory. Ever since, its people seem to have formed the habit of contributing to each revolutionary step ahead in communications.

For example, they helped to take the electronic tube out of the laboratory, and put it to work for everybody, by producing one of the first such tubes to be manufactured on a commercial scale.

For the past four years, every ounce of our engineering and production experience has been at work for Uncle Sam. Postwar American industry will naturally seek to draw on the *know-how* developed during the war. Ours applies not only to communications, but to the general field of electronics and precision electrical engineering and manufacturing. If you have a problem involving communications, product improvement, product control, ignition, or the manufacture of precision electrical devices, our particular *know-how* is at your disposal.

ARMY E NAVY

GAI

CONNECTICUT TELEPHONE & ELECTRIC DIVISION

GREAT AMERICAN INDUSTRIES, INC.

MERIDEN, CONNECTICUT

TELEPHONIC SYSTEMS • SIGNALLING EQUIPMENT • ELECTRONIC DEVICES • ELECTRICAL EQUIPMENT • HOSPITAL AND SCHOOL COMMUNICATIONS AND SIGNALLING SYSTEMS • IGNITION SYSTEMS

Alcoa's giant precision-testing and metal-working machine

Aluminum alloys being given a precipitation heat treatment in a constant temperature oil bath

ALUMINUM RESEARCH LABORATORIES

THESE *Ivy-Covered* WALLS ARE A SYMBOL

A foundation solid as only a quarter century of competent research can make it—a structure of accumulated scientific knowledge interpreted by mature thinking—chemists, metallurgists and engineers with the realistic urge that "aluminum must be made to work harder *today*"—the finest of modern equipment. This is Aluminum Research Laboratories.

This is the reason why, when the emergency of World War II threatened, research didn't have to be started. It had been under way here for years.

Light metal alloys had been invented to meet practical conditions. Methods of producing aluminum, of fabricating and assembling it, were developed. This information was disseminated among the companies from which today's miraculous applications of aluminum have sprung.

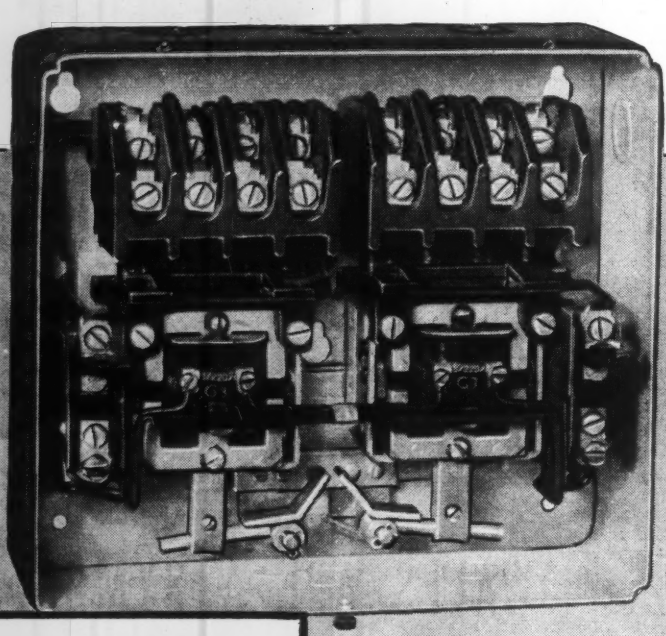
Alcoa research can mean a lot to you during these wartimes and postwar. The illustrated booklet published at the time of the twenty-fifth anniversary of Aluminum Research Laboratories will give you a quick picture of their activities. For a copy, write ALUMINUM COMPANY OF AMERICA, 1940 Gulf Building, Pittsburgh 19, Pennsylvania.

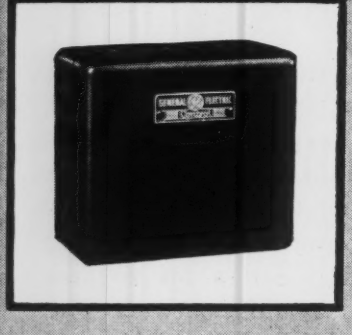
ALCOA ALCOA ALUMINUM REG. U. S. PAT. OFF. **ALUMINUM**

—Designer's—

New REVERSING STARTERS THAT POLICE ARCING

Announcing a simple new mechanical INTERLOCK





Designed to "go well" with modern machines, these trim reversing starters (Types CR-7009-B50 and B51) are equipped with the new G-E mechanical interlock for short-circuit protection. Multi-speed starters (Types CR7107-K50 and K51) are also equipped with this new G-E device.

ARCING that occurs when a contactor op during reversing is a virtual "fifth colum bridge for possible damaging short-circuit cu rents, if the arc is not extinguished *before* i companion contactor closes. To minimize th hazard, General Electric has developed a ne mechanism that, for all practical purposes, pr vents its occurrence—the G-E semi-interferen mechanical interlock.

This new and inexpensive safety feature now standard on the CR7009 reversing start up to 1½ hp, single-phase, and up to 7½ h polyphase; also on the CR7107 multi-spe starters, up to 7½ hp.

These G-E magnetic starters are available several standard forms to meet your electric requirements and to fit in the space your desi allows. You can install them on your equi ment with full confidence in their performanc in their ability to handle the toughest loa that may be imposed upon them.

G.E. has many types, sizes and combinatio of controls, and a broad, versatile line of ele tric motors, for manual or automatic operati of machinery. To aid your selection, our applic tion engineers can give you unbiased recom mendations. *General Electric Co., Schenectady, New York.*

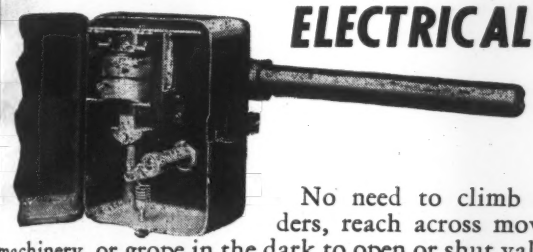
Buy all the BONDS you can—*and keep all you buy*

GENERAL ELECTRIC

Digest

TIMELY HIGHLIGHTS ON G-E PRODUCTS

OPEN HARD-TO-GET-AT VALVES ELECTRICALLY

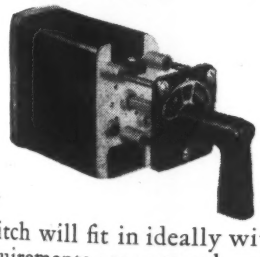


No need to climb ladders, reach across moving machinery, or grope in the dark to open or shut valves. It's much simpler, safer, and quicker to install a push-button operated G-E solenoid valve. The valve bodies are made of bronze, cast iron, monel metal, or cast steel, for a variety of service applications, in sizes up to 2 in. Other types available in larger sizes. Ask for Bulletin GEA-1423A.

FOR HIGH ACCURACY—LONG LIFE

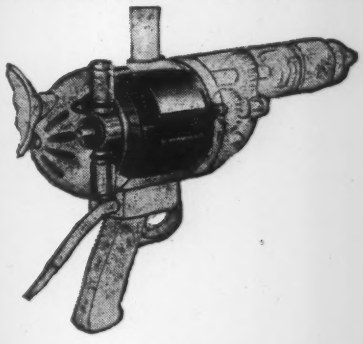
These thin, internal-pivot panel instruments have high torque, good damping, and a lightweight moving element that withstands vibration. They respond rapidly and accurately. They give you more instrument in less space, because the internal-pivot construction makes the entire element assembly 20 per cent thinner than outside-pivoted types. Write now for details of the Type DW voltmeter or ammeter—milli, micro, or radio frequency. Bulletin GEA-4064.

THERE ARE 4000 WAYS YOU CAN USE THIS SWITCH



For most ordinary control and transfer switching jobs, you'll find a standard SB-1 switch will fit in ideally with your designs. But where requirements are unusual, special switches can be made from standard cams, contacts, and other parts. Already, more than 4000 different arrangements have been made. Every circuit designer should have a copy of the booklet that describes the flexibility of this switch. Ask for Bulletin GEA-1631D.

The case of the DISAPPEARING MOTOR



For your designs that call for hidden motors, G.E. can furnish several types, including shell-type squirrel-cage motors (stator and rotor only), series-motor parts (stator, wound rotor, and brush mechanism), and governor-controlled series motors completely assembled for mounting inside machines. You have complete freedom of design in incorporating these basic motor components as a built-in power source.

More and more portable tools, machines, and appliances are being electrified by motors that "disappear" within a form-fitting "case" designed by the product manufacturer. The phantom view, for example, shows a set of high-speed, series-motor parts that form an integral part of a drill assembly, yet are out of sight of the user.

Operating speeds: shell-type motors, up to 120,000 rpm; series-motor parts from 2000 to 14,000 rpm; governor-controlled units, 2000 rpm. Ask for detailed information on the particular type of disassembled motor components, or assembled units, to handle your next "inside" job.

General Electric Company, Section B668-34
Schenectady 5, N. Y.

Please send me the following bulletins:
GEA-1423A—solenoid valves.....
GEA-4064—instruments.....
GEA-1631D—SB-1 switch.....
GEA-4092—built-in motors.....

NAME.....
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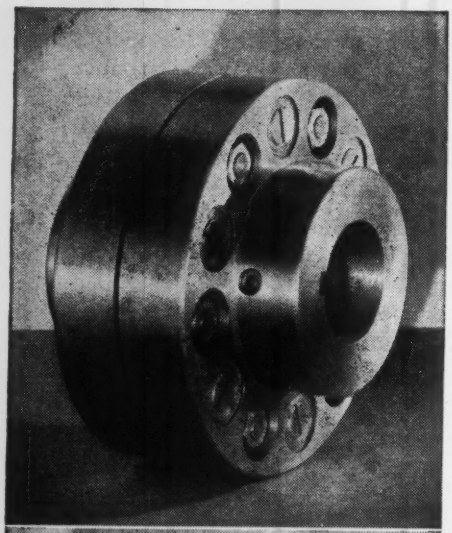
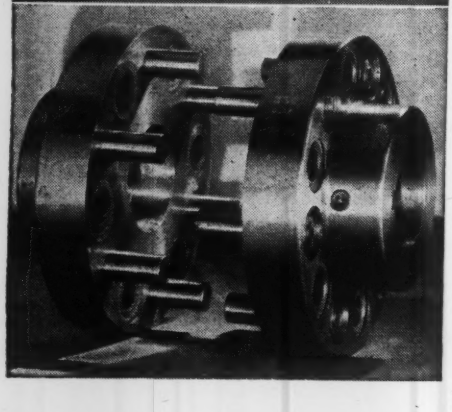
STREET.....
CITY.....STATE.....

8579





We dare you...

Just take a couple of pencils right now and try to hold them in perfect alignment without touching each other while you count 10.

Remember that you are making this 10 second test with pencils weighing a fraction of an ounce. At the same time, remember that all the horsepower goes through the coupling connecting heavy machines running at high speed hour after hour.

Ajax Flexible Couplings have been doing this job for over 20 years. They do it without lubrication because of their rubber bushed, graphited-bronze bearings and interlocking drive studs.

Write for the facts on Ajax Flexible Couplings.

AJAX

ARMY E NAVY

FLEXIBLE COUPLING CO.

Incorporated 1920

WESTFIELD, N. Y.

BY THE DROP OR BY THE GALLON

THIS DUMORE MOTOR HAS AN UNUSUALLY WIDE RANGE OF OPERATION!

Its job right now is to drive a metering pump, delivering anti-icing fluid to airplane propeller blades. Here are some of the unusual conditions it must meet to satisfy the requirements of its vital function: Its speed is controlled by a rheostat to provide a flow of from two and one-half to thirty gallons per hour!

When the minimum flow is required the pilot turns the knob from "off" to "low" and the motor must *start* and *run,* on even the *minimum current.* At whatever setting of the rheostat, the motor speed is expected to be relatively stable, unaffected by such external conditions as temperatures up to 160° F. or down to 65° below zero.

This motor, and the other thirty-odd Dumore Aeromotors, now aiding in various ways to bring a victorious end to the war, will one day supply the power for many varied motor driven devices now being planned.

Engineers and manufacturers — learn *now* the many advantages in planning your post-war products around the distinctive features of Dumore motors, for greater service, sales appeal, profit. Write today for interesting descriptive literature. Address The Dumore Company, Motor Division, Dept. MM25, Racine, Wisconsin.

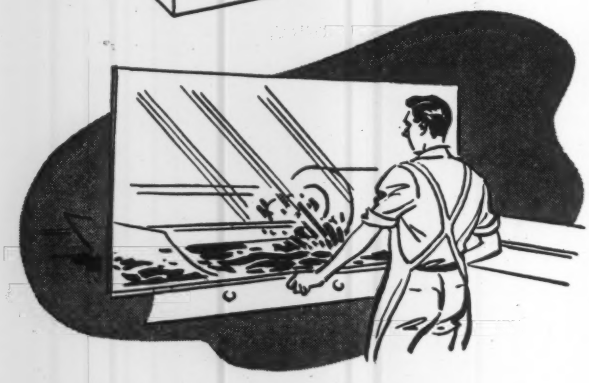
FOR *Extra* POWER HOURS

"MOTOR-PLAN" YOUR POST-WAR PRODUCT, NOW!

DUMORE

HEADQUARTERS FOR FRACTIONAL HORSEPOWER MOTORS

. . . how industry can provide visibility and protection . . . with *Glass*



FOR PERSONNEL Where equipment may splash or spray acids or throw minute particles, safeguard workmen with a screen of glass. If a process generates dangerous or uncomfortable heat, provide a screen of L·O·F Tuf-flex—the glass that is tempered for thermal shock.

FOR MATERIAL IN PROCESS If you produce foods, chemicals, drugs or finely-machined parts that must be kept immaculately clean—confine those processes to glass-enclosed rooms. Glass enables you to keep the rooms "open" for light and visibility—yet closed from harmful elements.

FOR EQUIPMENT Is the machine running properly? Does it need lubrication? Is the flow of materials steady and unhampered? Safeguard your equipment by putting a window of glass in it—so you can *see* trouble before it becomes serious.

GLASS has the transparency, the hardness, the chemical and dimensional stability, the weather-resistance—to do many jobs for industry. It can be tempered for extra strength, for extra resistance to impact and thermal shock.

If you desire visibility in any of your processes, equipment or buildings—chances are that glass can do the job for you. We'd welcome an opportunity to show you how. Libbey·Owens·Ford Glass Company, 21124 Nicholas Building, Toledo 3, Ohio.

L O F

LIBBEY·OWENS·FORD

a Great Name in **GLASS**

Destructive heat...brittle cold

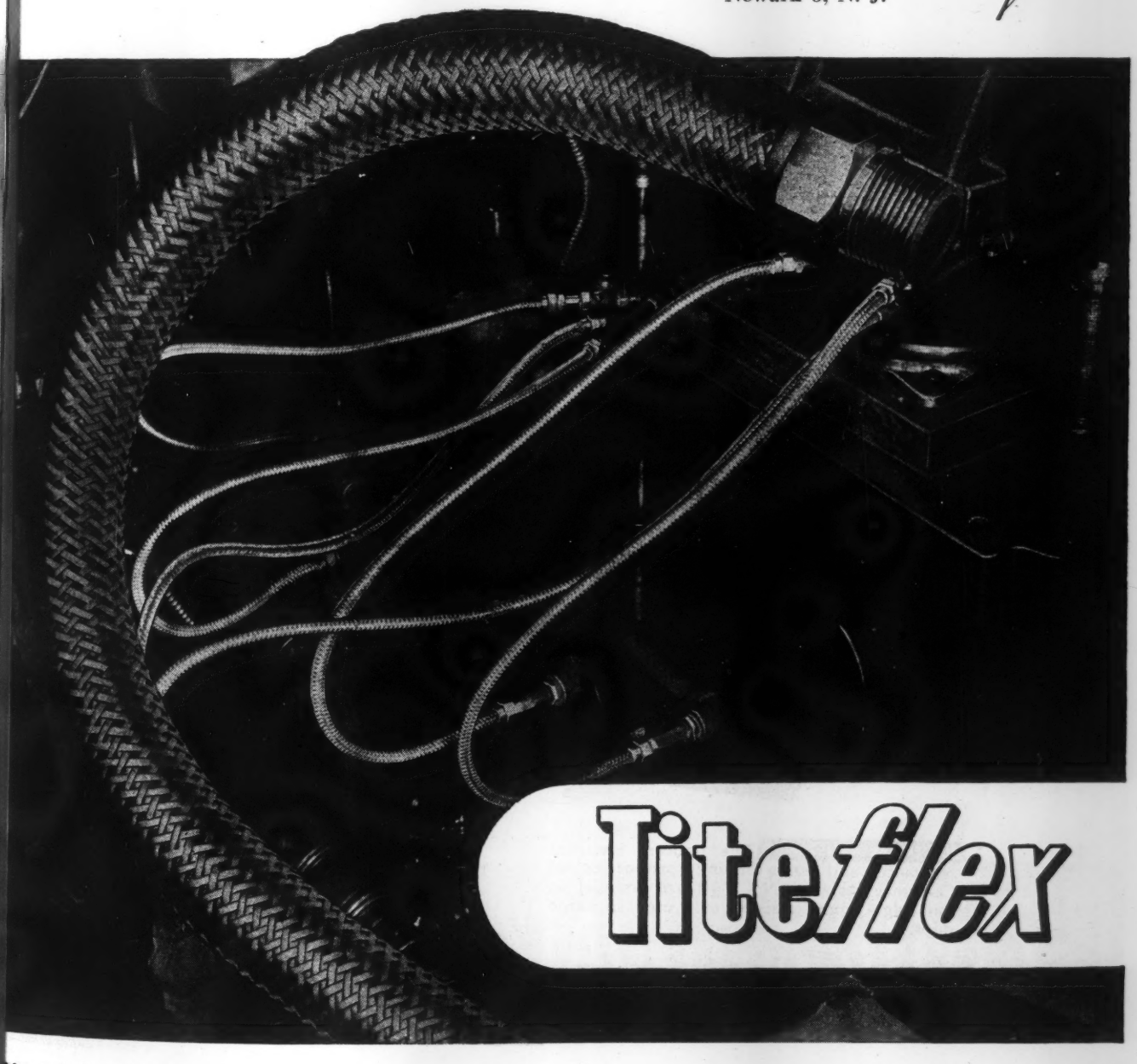
TITEFLEX FLEXIBLE TUBING remains flexible and pressure-tight under the widest range of temperature variations. We think, for instance, that you'll be interested in the problem of a phonograph record manufacturer . . .

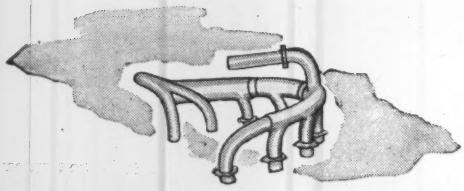
• He makes records on presses like the one in our illustration, and he found the solution to supplying both *steam* and *cold* water to the stationary and movable platens by choosing Titeflex all-metal tubing.

• What a change from the temperatures and pressures of steam applications to -50°F. of high-altitude aircraft installations. Yet Titeflex remains perfectly flexible at -50°F., while other types of tubing become brittle from the low temperature. In addition — because it's *all-metal* — Titeflex is not affected by the destroying influence of oils, gasoline, and most chemicals.

• Undoubtedly the versatility of Titeflex will find many applications in your own plant for your wartime or postwar planning. We'd like you to write for our catalog No. 113 which gives specifications on Titeflex and which suggests many applications of which you might not otherwise think.

TITEFLEX, INC.
532 Frelinghuysen Avenue
Newark 5, N. J.

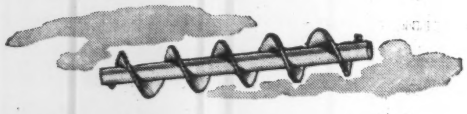




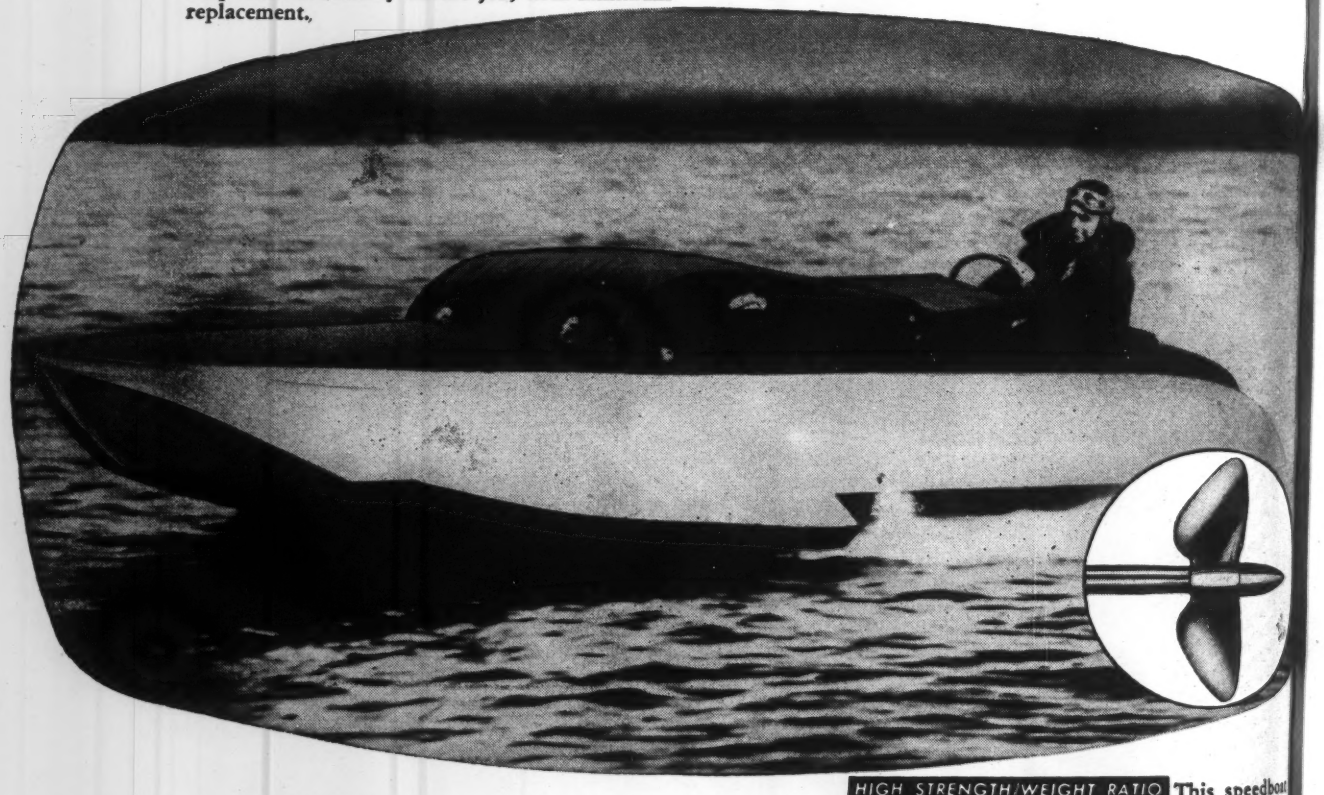
You Get

CORROSION RESISTANCE

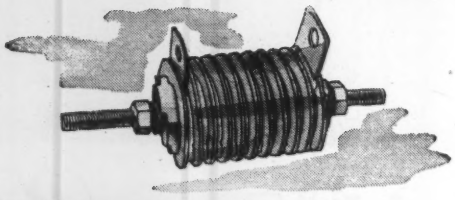
HEAT RESISTANCE Carpenter Stainless No. 4-TI or No. 4-CB used in the aircraft exhaust manifolds like that shown above, are typical of a wide range of Stainless grades that meet high temperature service requirements.



WEAR RESISTANCE Stoker worms like this in thousands of homes and industrial plants can be installed and forgotten because Carpenter Stainless Steels Nos. 4 & 6 provide the wear and corrosion resistant qualities necessary to keep them constantly on the job, with minimum replacement.



HIGH STRENGTH/WEIGHT RATIO This speedboat propeller shaft, made from Carpenter No. 4 Free-Machining Stainless transmits maximum horsepower through a minimum diameter. The shaft must remain absolutely straight, even when subjected to sudden power and torque thrusts. And this Stainless provides ample protection against salt water corrosion. If you are looking for similar advantages in your postwar products, investigate easy-working Carpenter Stainless Steels now!



ELECTRICAL RESISTANCE The uniform electrical resistance and easy-forming properties of Carpenter Stainless No. 1-JR are essential in this edge-wound resistor coil used in cargo ships.

Plus these

SPECIAL PHYSICALS

with Carpenter Stainless!

Have you considered the many advantages that can be obtained for your new or redesigned products through the special physical properties provided by Carpenter Stainless Steels? On these pages we attempt to show you some of the many physicals that are available to you in various Carpenter Stainless grades. Right here may be the answer to giving your postwar products greater utility, broader sales appeal.

Carpenter, as pioneer in the development of soft and ductile Stainless Strip and inventor of Free-Machining Stainless bar stock—has always made a specialty of producing Stainless Steels to do specific jobs. Our experienced representatives can help you select the Carpenter Stainless grades whose physical properties most fully meet your requirements. Careful laboratory control and exacting inspection assure consistent uniformity, lot after lot, in the Stainless you receive.

This service means that when your designer specifies Carpenter Stainless he can secure the special physicals he desires, as well as easiest fabricating qualities. This all adds up to faster production, fewer rejects, and lower unit costs for your postwar products.

Give Your Products These Advantages

- Sales Appeal
- Everlasting Beauty
- Freedom from Rust
- No Plating to Peel
- Weight Saving
- Strength and Rigidity
- Ease of Assembly
- Fewer Service Complaints

Call in your nearby Carpenter representative now and take full advantage of his diversified Stainless experience in helping to get the best results with Stainless. But do it today, for planning time is getting short.

THE CARPENTER STEEL COMPANY, 120 W. BERN ST., READING, PA.

Carpenter STAINLESS STEELS

BRANCHES AT Chicago, Cleveland, Detroit, Hartford, St. Louis, Indianapolis, New York, Philadelphia

Milling THE SHAPE OF THINGS TO COME

Many of the new products of the future will be different—very different—yet when stripped down to fundamental design elements, there'll still be the same flat and curved surfaces to machine. Machining *methods* already are undergoing radical changes. A typical example is the adaptation of a recently-announced Westinghouse electronic device, the Mot-O-Trol, to a universal milling machine.

On this machine, the contour of the work-piece is obtained mechanically—but with the Mot-O-Trol, the feed rate is kept at a uniform number of feet per minute, automatically, regardless of irregularity of contour.

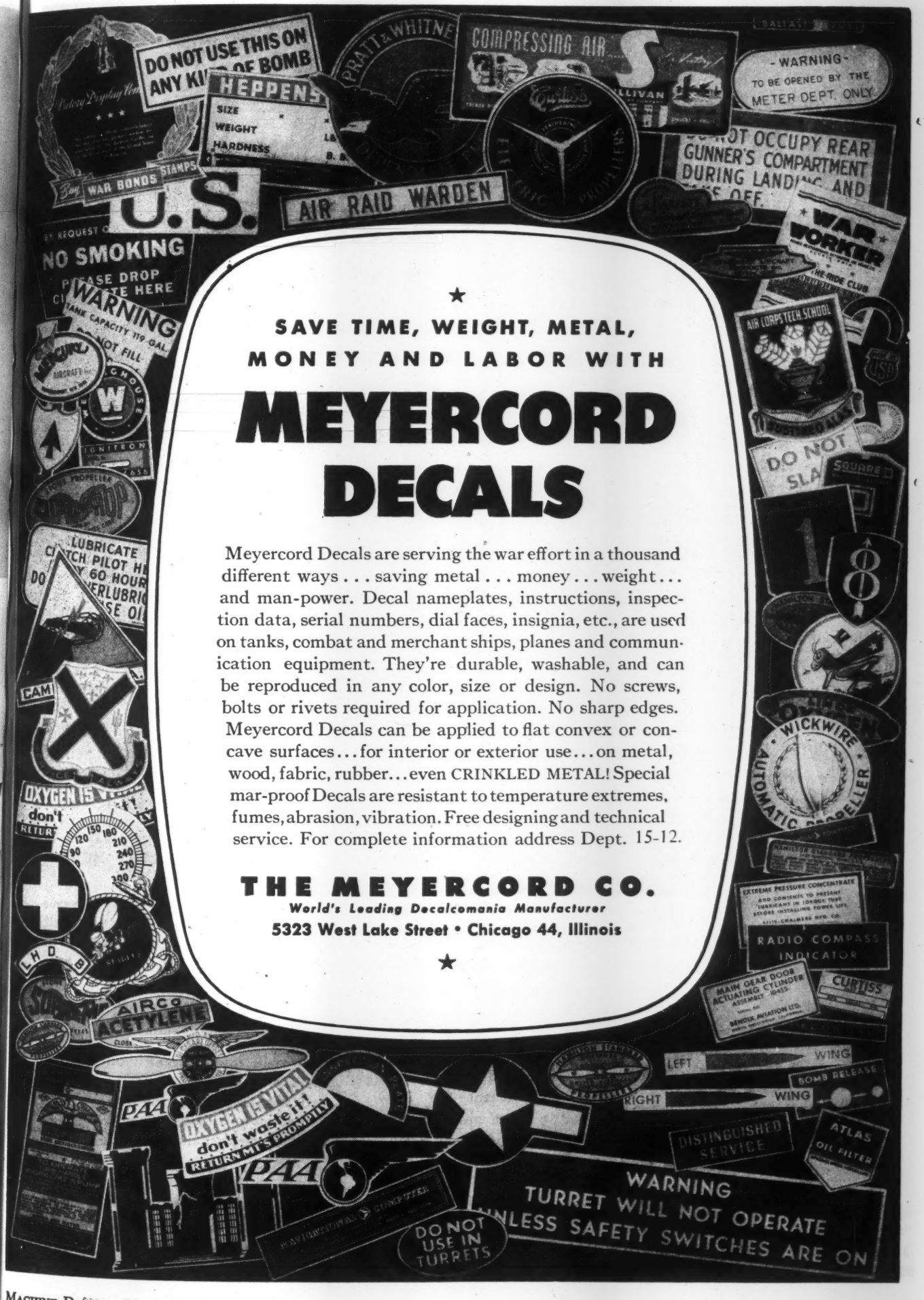
This electronic control equipment, equally adaptable to other types of machine tools, is only one of many new Westinghouse developments in machinery electrification. For years, machine tool builders have relied on Westinghouse for simple electrical solutions to complex mechanical problems. When you need this kind of help, call your nearest Westinghouse representative. Westinghouse Electric & Manufacturing Company, Box 868, Pittsburgh 30, Penna.

J-94

Westinghouse

PLANTS IN 25 CITIES OFFICES EVERYWHERE

THE MACHINE IN MACHINE TOOLS



★

SAVE TIME, WEIGHT, METAL, MONEY AND LABOR WITH

MEYERCORD DECALS

Meyercord Decals are serving the war effort in a thousand different ways . . . saving metal . . . money . . . weight . . . and man-power. Decal nameplates, instructions, inspection data, serial numbers, dial faces, insignia, etc., are used on tanks, combat and merchant ships, planes and communication equipment. They're durable, washable, and can be reproduced in any color, size or design. No screws, bolts or rivets required for application. No sharp edges. Meyercord Decals can be applied to flat convex or concave surfaces . . . for interior or exterior use . . . on metal, wood, fabric, rubber . . . even CRINKLED METAL! Special mar-proof Decals are resistant to temperature extremes, fumes, abrasion, vibration. Free designing and technical service. For complete information address Dept. 15-12.

THE MEYERCORD CO.

World's Leading Decalcomania Manufacturer

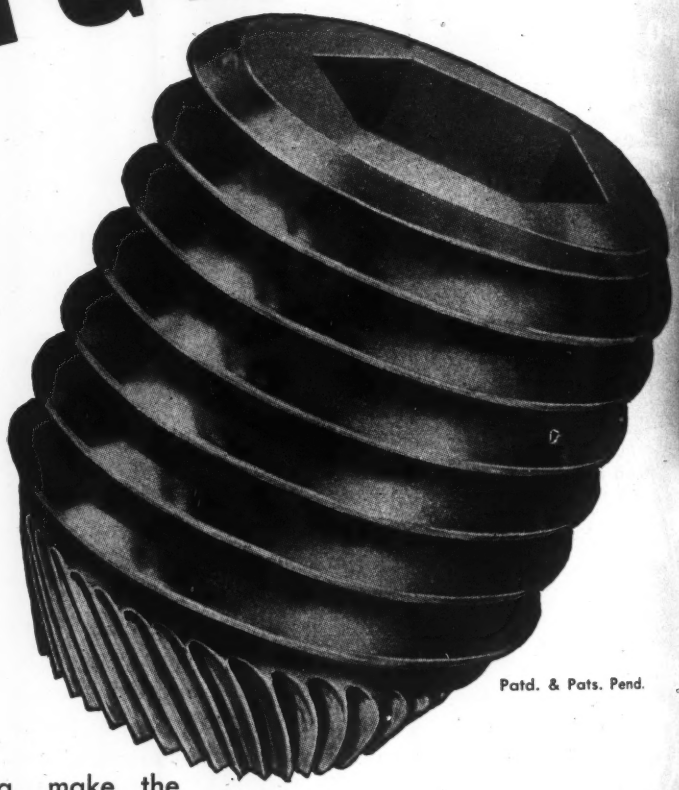
5323 West Lake Street • Chicago 44, Illinois

★

SOMETHING FOR DESIGNERS!

UNBRAKO

Reg. U. S. Pat. Office



Patd. & Pats. Pend.

HOLLOW SET SCREW
with the Knurled Cup Point

It's a Self-Locker and *won't work loose.* The knurls of the point dig in and hold tight. Even so, it is easily backed out with a wrench, and can be used again and again without impairment to its self-locking ability.

This unique locking feature, plus strength, hardness and accurate threading, make the "UNBRAKO" Self-Locker one which you can incorporate with confidence.

For further information send for the "UNBRAKO" Catalog.

Sizes in Hollow Set and Cap Screws from No. 4 to 1½" diameter. Full range of lengths.

Patented

OVER 40 YEARS IN BUSINESS

"UNBRAKO" HOLLOW SET SCREW WITH KNURLED THREADS

Where the "Unbrako" Cup Point Self-Locker is not suitable, use our Knurled Thread "Unbrako," which, regardless of the style of point, is also a Self-Locker. Magnified section of cut at left shows the locking feature and angle of knurls. These positively prevent the screw from unwinding once it has been set.

And also "UNBRAKO" KNURLED SOCKET HEAD CAP SCREW

It's a time-saver. Fingers become geared to the knurls of the head, thereby permitting the screw to be turned farther and faster by hand before a wrench is needed. Again, a saving in material, weight and cost, are possible with this screw, since its round socket head requires less clearance for application than the ordinary hex head — hence more compact designs.

Knurling originated with "Unbrako" years ago.

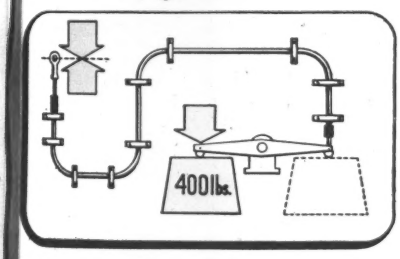
STANDARD PRESSED STEEL CO.

JENKINTOWN, PENNA., BOX 102 • BRANCHES: BOSTON • DETROIT • INDIANAPOLIS • CHICAGO

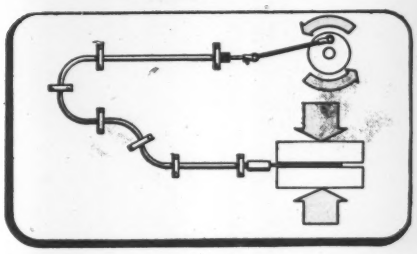
Dependable *all around duty assured with* Simmonds Push-Pull Controls

FIRST TO CARRY THE YELLOW DOT

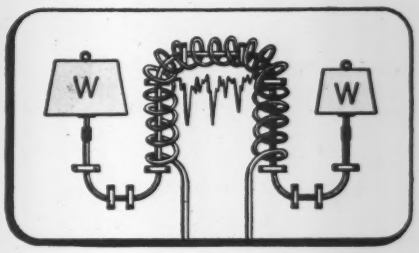
of Army Air Force Winterization acceptance for operation in extreme temperatures is the Simmonds-Corsey Push-Pull Control. Comprehensive tests with temperatures as low as minus 72°F. and as high as 160°F. prove efficient operation under wide variety of conditions.



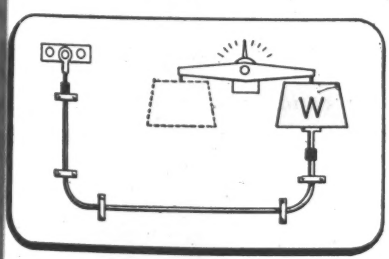
STATIC STRENGTH: *In this test Simmonds push-pull control successfully withstands tensile and compressive forces of 400 lbs. Credit simplification of design, improved linkage.*



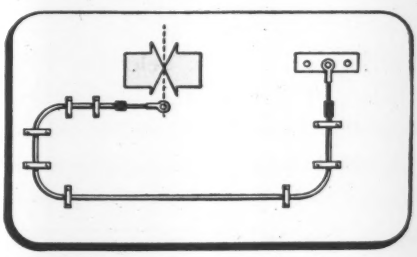
ENDURANCE: *Cycled 30,000 times under stress, as illustrated, Simmonds controls are not affected in any way, and can be expected to outlast the life of unit served.*



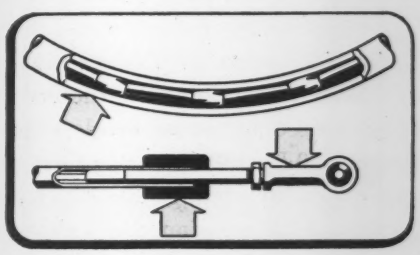
EFFICIENCY: *Input-output ratio of control is measured at various temperatures in insulated chamber. Result: average efficiencies are twice the AAF requirements.*



PRECISION CONTROL: *Motion between tension and compression is negligible. Before endurance test: average—.046"; after—.082". Simmonds are precision-built controls.*



DEFORMATION: *AAF specifications call for loads ranging from 10 to 50 lbs. Allowable average deformation is .140". Simmonds controls average only .083".*



CORROSION: *Simmonds controls meet AAF specifications for corrosion resistance with standard cadmium plated or anodized surfaces. Tube ends are rubber sealed.*

INQUIRIES concerning War Contracts or Post-War problems involving push-pull control equipment are invited. Our service engineers will furnish you gladly with analyses and recommendations. Telephone or write to your nearest Simmonds office.

SIMMONDS EQUIPMENT FLIES WITH EVERY TYPE OF ALLIED AIRCRAFT

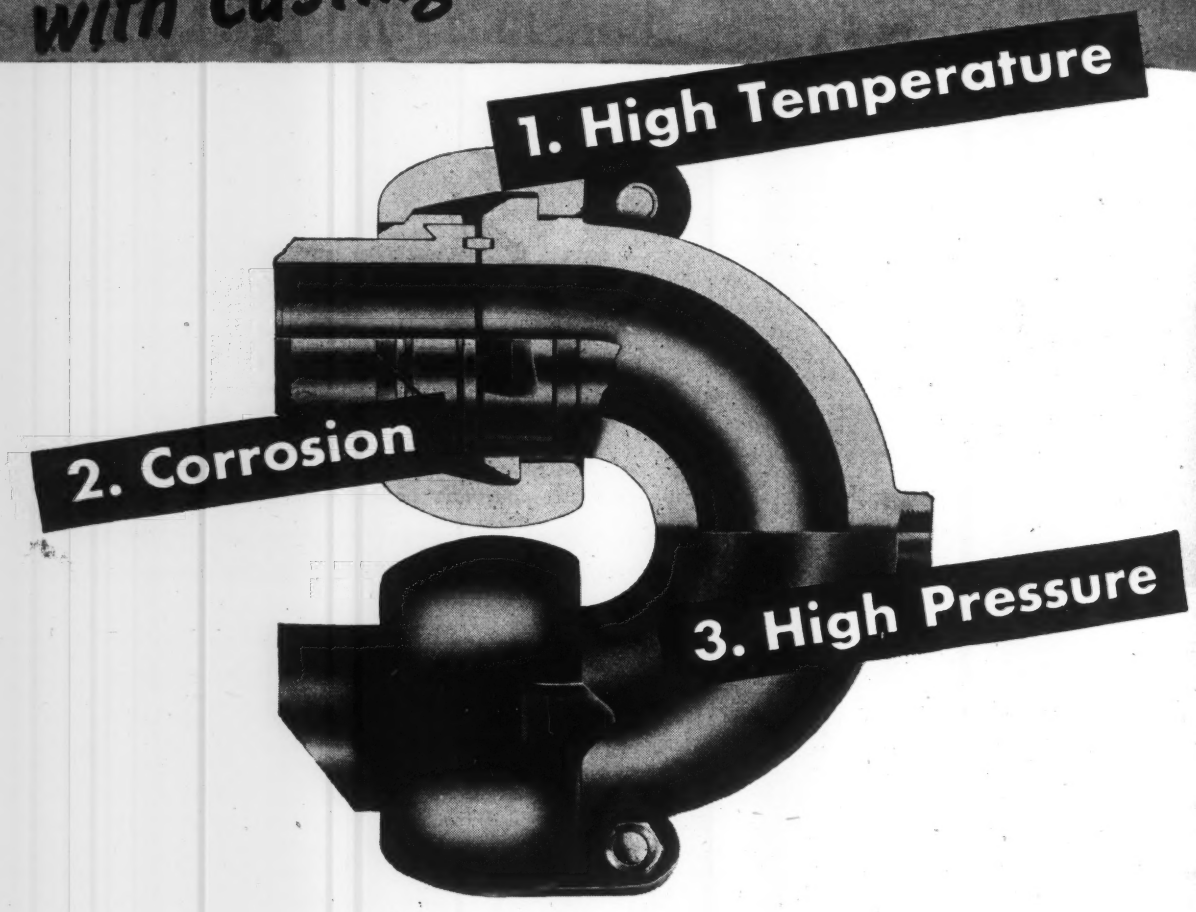
Automatic Engine Controls — Push-Pull Controls — Spark Plugs
Hydraulic Accumulators — Hydraulic Fuses — Chronometric Radiosondes
Self-Aligning Rod-End Bearings — Fasteners and Clips of Specialized Design

30 Rockefeller Plaza,

SIMMONDS AEROCESSORIES INC.

New York 20, New York

Resist All 3 with Castings of Lebanon CIRCLE L 46



In oil refining and chemical processing, it is often necessary to specify an alloy that will resist a combination of high temperature, corrosion and high pressure.

Use of Lebanon Ⓛ46 solves the problem of resistance to this combination of destructive conditions. Lebanon Ⓛ46 is used in return bends where temperatures run above 1500 F. and where pressures are high. It also finds application in castings for superchargers and hot gas turbines. Scale resistance of Lebanon Ⓛ46 is definitely greater than that provided by any 18% chrome and 8% nickel alloy. It is particularly resistant to fuels relatively high in sulphur. Good strength and rigidity are maintained at all temperatures up to 1850 F.

The increasingly severe use to which return bends are being subjected makes Lebanon Ⓛ46 an alloy of prime importance. Anyone concerned with the designing or specification of such equipment should become familiar with this material.

Selection of any heat resistant alloy is, of course, dependent upon service conditions. These should be carefully studied. Lebanon foundry engineers and metallurgists will be glad to help you conduct such a study for your future reference.

Chemical Analysis of Lebanon Ⓛ46		
Cr. 25%	Ni. 20%	C. .20 Max.

LEBANON STEEL FOUNDRY **LEBANON, PA.**

ORIGINAL AMERICAN LICENSEE GEORGE FISCHER (SWISS CHAMOTTE) METHOD

LEBANON CIRCLE L *Alloy and Steel* **CASTINGS**

A NEW AVIATION CATALOG!

Weatherhead "A-N" Fittings—Now and Postwar

The Weatherhead Company were pioneers in the manufacture of aircraft fittings. Many of the most important design changes on aircraft fittings were originated by Weatherhead. Our facilities, now and *in the future,* will be directed to the volume production of high-quality fittings, hose assemblies, valves, and actuating cylinders. All of the necessary designs, specifications, and photographs on these products are contained in our new Aviation Catalog.

SAVE TIME SAVE MONEY SAVE EFFORT

Write for this handy source book today.

SIX SECTIONS
for quick reference

- **AN Fittings**
- **AC 811 Fittings**
- **Flexible Hose**
- **Hose Assemblies**
- **Valves and Cylinders**
- **Complete Engineering Data**

Weatherhead Engineers will be glad to work with you to solve your fittings and hose assemblies problems. Our new Development Laboratory is at your disposal for the creation of new fittings and other products to meet your special requirements.

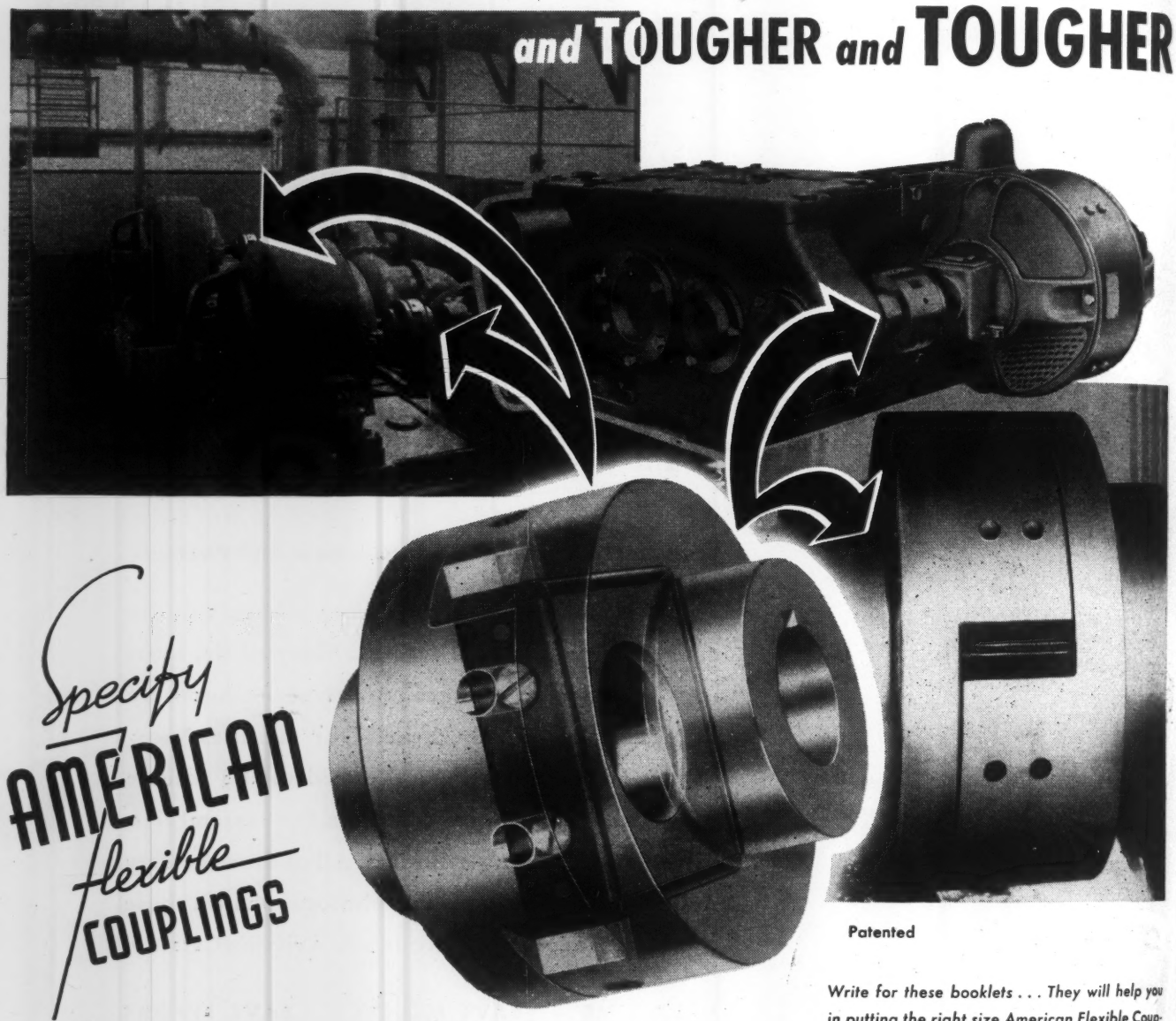
Look Ahead With

Weatherhead

THE WEATHERHEAD COMPANY, CLEVELAND, OHIO

One of the Oldest and Largest Manufacturers of Vital Parts for the Aviation Industry

When the Going Gets TOUGHER
and TOUGHER *and* TOUGHER



Specify AMERICAN *flexible* COUPLINGS

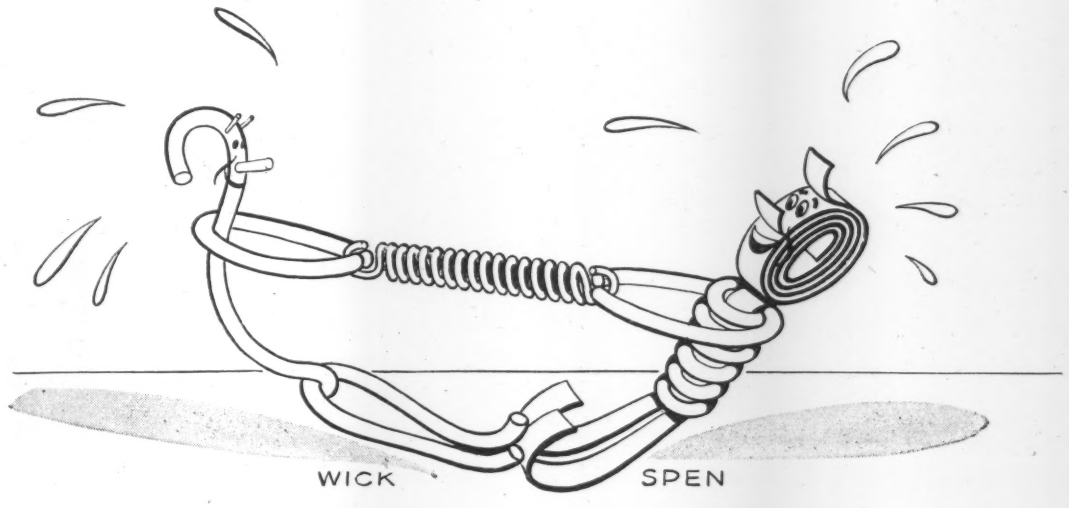
Patented

. . Because American Flexible Couplings are meeting all power take-off requirements without friction loss. This maximum power transmission is due to the simple American design . . . ***3 sturdy parts only—2 identical forged or cast jaw flanges connected by a square floating center member of high strength alloyed metals . . . removable bearing strips . . .*** all easily identified in the above phantom view. And for each industrial application you can get the right size American Flexible Coupling. Illustrated above are light, medium and heavy American Flexible Coupling applications.

Write for these booklets . . . They will help you in putting the right size American Flexible Coupling to work on Your Power Take-off Problem.

ZURN

AMERICAN FLEXIBLE COUPLING CO.
DIVISION OF
J. A. ZURN MFG. CO., ERIE, PENNA.



For Springs with High Stress Values call WICK and SPEN

This Free Book Will Help You

Our book "Springs and Wire Forms" contains valuable technical information, formulae and tables relating to spring performance. Write today for your free copy. Spring Division, Wickwire Spencer Steel Company, New Bond Street, Worcester 3, Mass.

The dimensions of a spring are determined not only by load and deflection requirements, but by the elastic and fatigue limits of the material used in its manufacture. Establishing a proper relationship between these factors requires judgment based on engineering knowledge and experience.

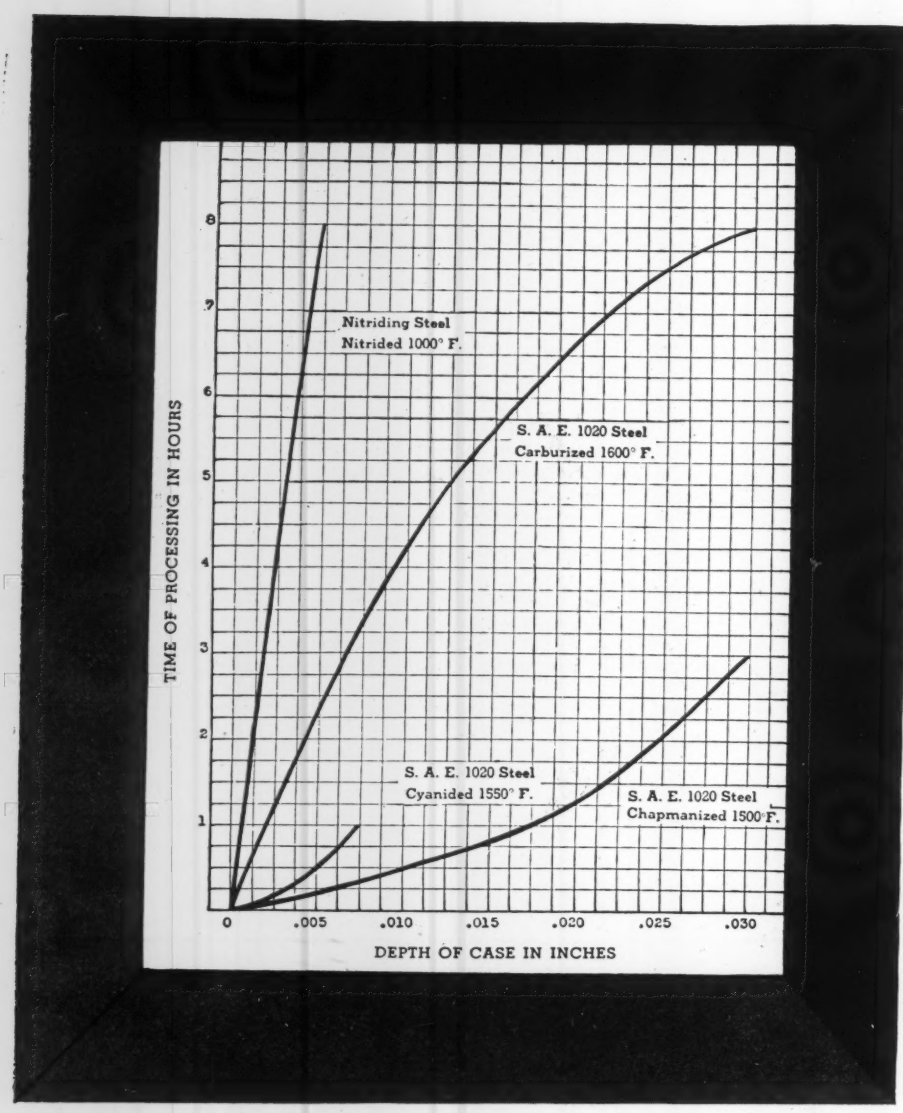
Because our spring and formed wire specialists have had years of experience they are often called upon to help solve perplexing problems involving the use of springs. We engineer every conceivable type of spring, and, to insure top-flight performance, we make the steel in our own open hearths—draw, form, temper and test it in our own mills.

If you are planning a post-war product requiring springs or formed wires we will be happy to be of service. Wickwire Spencer Steel Company, Spring Division, General Sales Office and Plant, New Bond St., Worcester 3, Mass.

WICKWIRE SPENCER STEEL COMPANY

EXECUTIVE OFFICES—500 FIFTH AVENUE, NEW YORK 18, N. Y.

Abilene • Buffalo • Chattanooga • Chicago • Detroit • Houston • Los Angeles • Philadelphia • San Francisco • Tulsa • Worcester



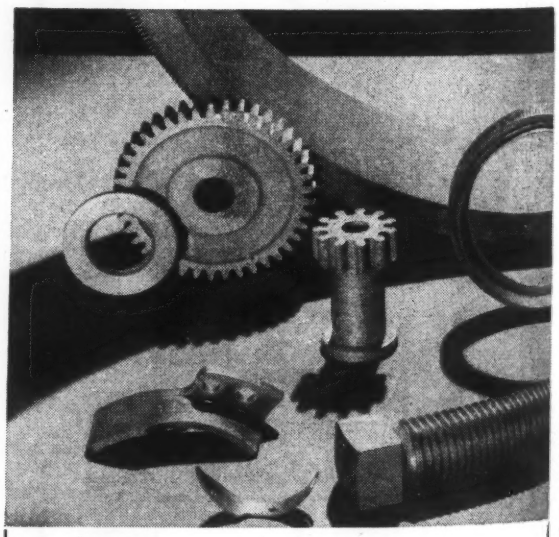
For Quick Surface-Hardening of Free-Machining Steels CHAPMANIZE

Note how quickly Chapmanizing gives free-machining steels an alloy-like surface-hardness. That's why, when specifications permit substitution, Chapmanized parts can save costly waiting for scarce and critical alloys.

Chapmanizing requires only 1 to 4 hours to produce a case from .002″ to .035″ deep — so tough and ductile that it won't chip, check or warp. With silver-clean surfaces — with distortion and growth reduced to a minimum — Chapmanized parts take less time, too, to finish grind.

For quick service send your parts to our Indian Orchard plant or to a Chapman licensed plant near you. Or if you prefer to do the work in your own plant on a contract basis we can hook up Chapmanizing units to your present pot-type furnaces.

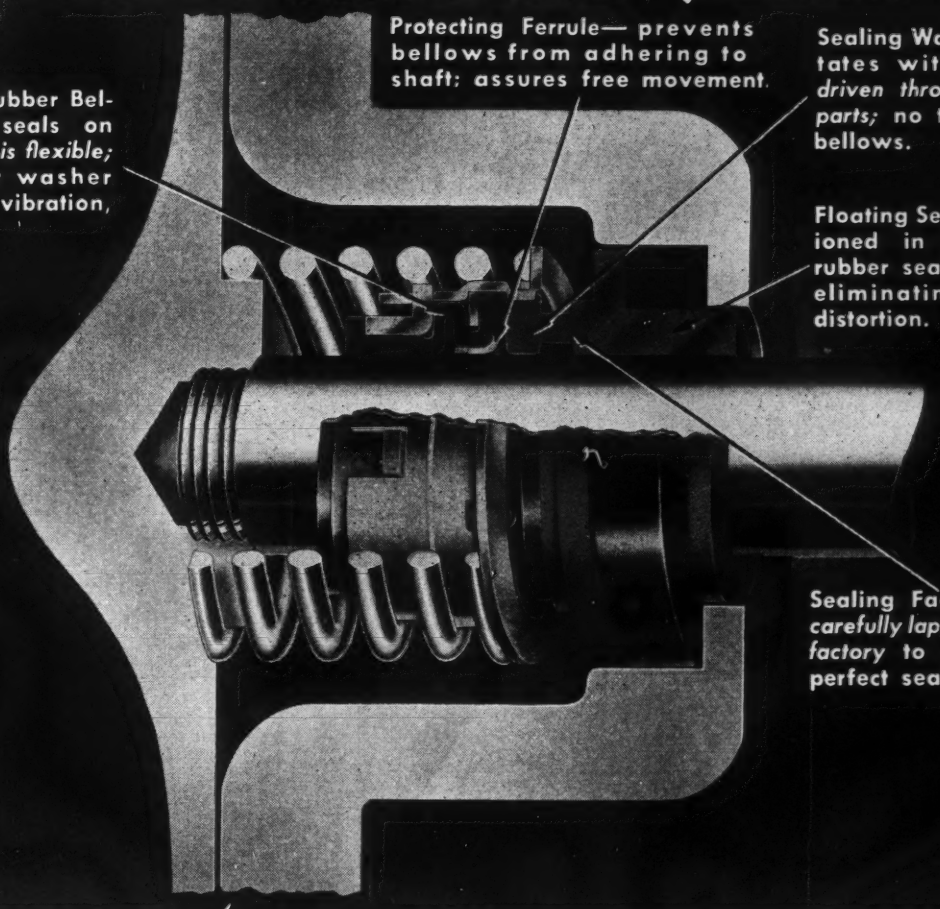
Let us send you complete information on this time and money saving process. Write to the Metallurgical Sales Division of:



There's **no time lost** waiting for delivery of critical alloys when you have free-machining steel parts Chapmanized.

The Chapman Valve Manufacturing Co., Indian Orchard, Massachusetts

5 OUTSTANDING *Features*



of the JOHN CRANE BELLOWS-TYPE *Shaft Seal*

This is a new, precision-built Shaft Seal already thoroughly proven on Centrifugal and Rotary Pumps, Speed Reducers, Refrigeration Compressors, Agitator Shafts and many other rotating shaft sealing applications.

Advantages:

- *Eliminates leakage, gland adjustment and shaft wear*
- *Reduces friction, saves power*
- *Operates effectively at high speeds and pressures*
- *Shipped as a complete unit, ready for installation*

The John Crane Bellows-Type Shaft Seal is made in two types: Type 1 for limited diameter; Type 11 (illustrated above) for limited length.

Design and Development Engineers—Send for Illustrated Bulletin

CRANE PACKING COMPANY

1825 CUYLER AVE. • CHICAGO 13, ILL.

BALTIMORE, BOSTON, BUFFALO, CLEVELAND, DALLAS, DETROIT, HOUSTON, LOS ANGELES, NEW ORLEANS, NEW YORK, PHILADELPHIA, PITTSBURGH, SAN FRANCISCO, ST. LOUIS, TULSA

CRANE PACKING CO., LTD., Hamilton, Ontario, Canada.
Branches: Montreal, Toronto, Vancouver

Craftsmen

ARE AS GOOD AS THEIR TOOLS . . . .

● Up at the Yale and Towne Manufacturing Company in Stamford, Connecticut, craftsmen have been making the well-known "Yale" locks and builders' hardware for many years. The enviable reputation enjoyed by this company is the result of their insistence for fine quality.

Now as a major contributor to the war effort, Yale and Towne are producing hydraulic pistons and cylinders. Constantly endeavoring to improve their already superior quality, they use the Brush Surface Analyzer in both laboratory and shop. With this instrument they are able to study surface finishes, accurately measured to one millionth of an inch (.000001") from chart recordings instantly made as the specimen surface is explored.

THE BRUSH DEVELOPMENT COMPANY

3463 PERKINS AVENUE • CLEVELAND 14, OHIO

Designing Molded Plastics Parts: LOW TEMPERATURES

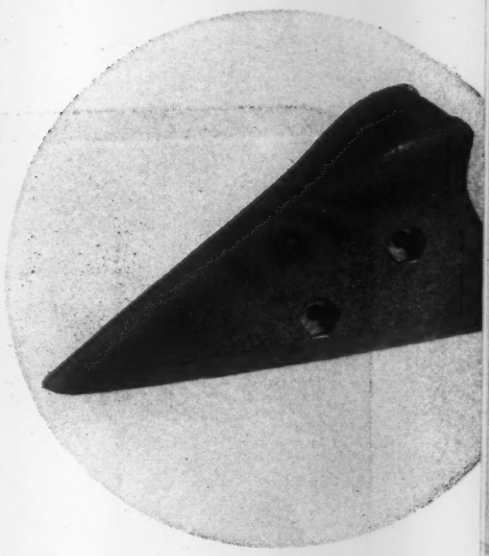
From the engineering files of One Plastics Avenue

Plastics are much more sensitive to relatively slight changes in temperature than are the metals. This reflects itself principally in a change in mechanical properties, although electrical and chemical properties are also affected.

Because they are "plastic," plastics show an increasing tendency to cold flow as the temperature increases, and conversely, an increase in rigidity as the temperature decreases. This increase in rigidity makes the material stiffer and more brittle, which reflects itself in an increase in tensile strength and modulus of elasticity and a decrease in impact strength. This is especially true of most of the thermoplastics.

Thermosetting materials, such as the phenolics, ureas, and melamines, are more rigid because of their cross linked structure, and are comparatively unaffected by a decrease in temperature.

Applications in which these considerations are especially important are parts for aircraft which are commonly subjected to −40°C. Refrigerator parts may also be subjected to sub-zero temperatures. Extruded plastic tubing may have to retain its flexibility at very low temperatures. Thermoplastics to be used outdoors may have to be especially selected for low temperature use.



This molded airplane fairing retains its high impact strength when tested at a temperature of −80° C.

Mechanical Properties At -80°C As Compared To Those At 25°C

	Tensile	Impact	Modulus of Elasticity
Phenol - Wood flour	100%	100%	130%
Fabric	120%	80%	
Asbestos	110%	105%	
Urea			140%
Melamine		100%	
Polystyrene	170%	100%	140%
Methacrylate	150%	100%	> 200%
Cellulose Acetate	200%	20%	120%
Ethyl Cellulose	150%	20%	

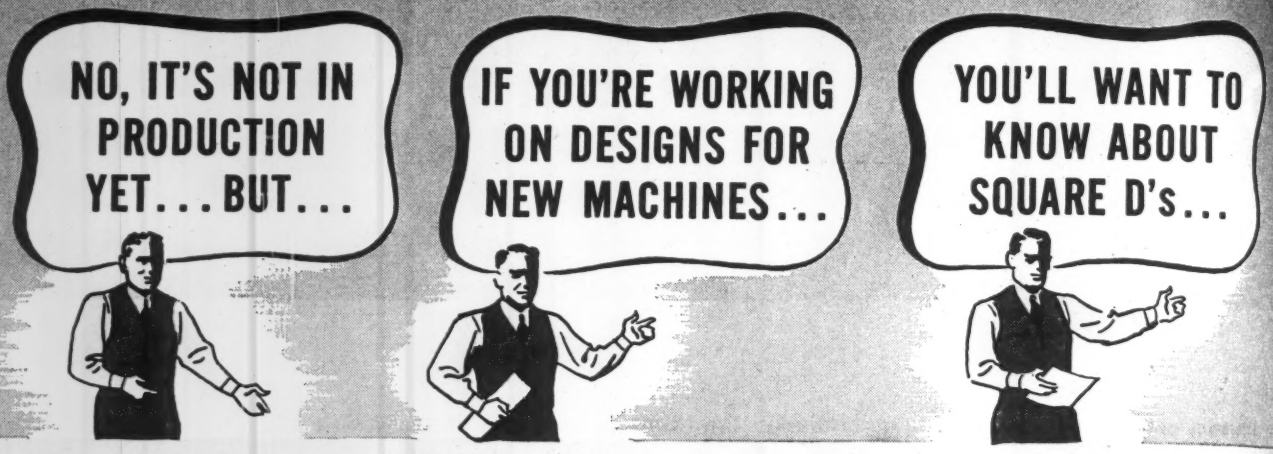
REPRINTS **of this advertisement may be obtained by writing Section E-223 General Electric Plastics Divisions, One Plastics Avenue, Pittsfield, Mass.**

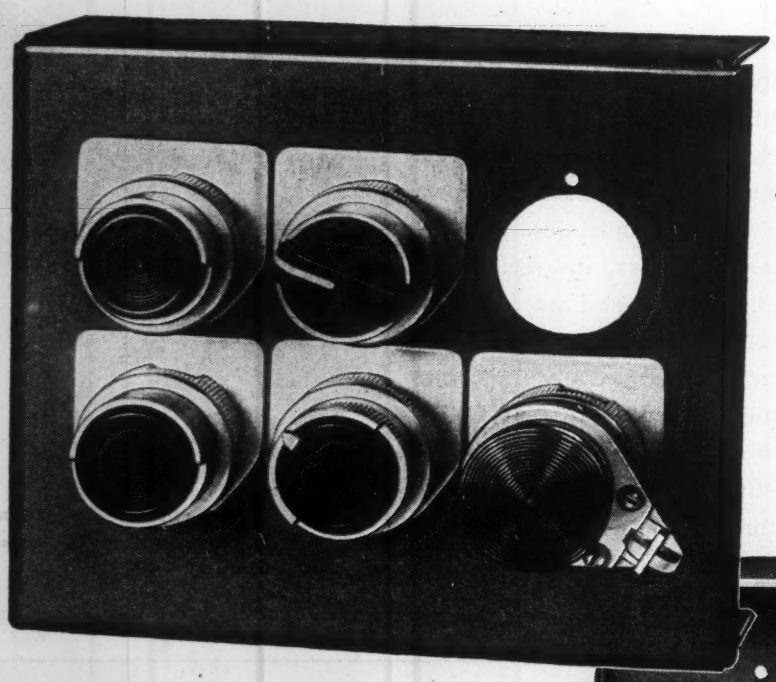
Hear the General Electric radio programs: "The G-E All Girl Orchestra" Sunday 10 P.M. EWT, NBC. "The World Today" news every weekday 6:45 P.M. EWT, CBS.

BUY WAR BONDS

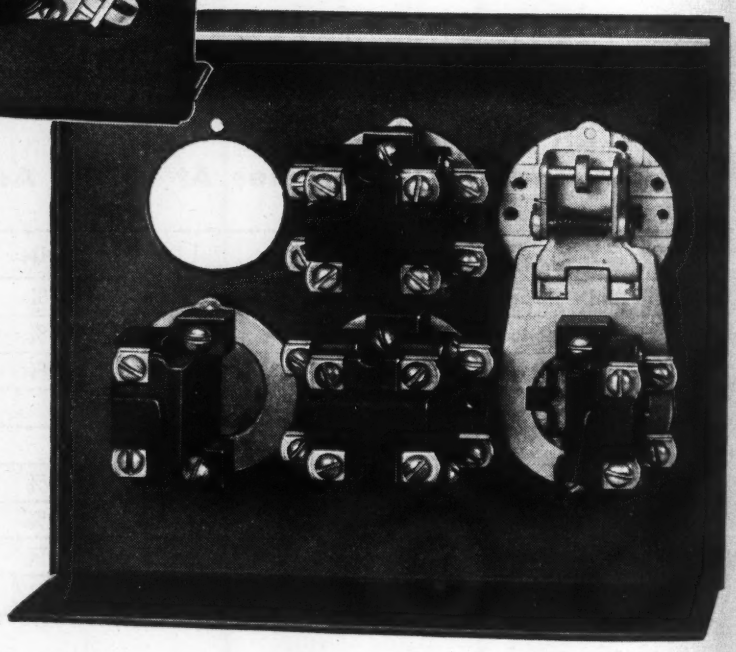
PD-4

GENERAL ELECTRIC





Note the compactness of these heavy-duty buttons which permits them to be mounted on close centers. Blank space in top row shows simplicity of mounting preparation. Lower center unit is the new, unique Start-Jog button described on right hand page.



Center units are double pole, double throw; others are standard double circuit. Rear view shows maintained contact assembly of two push buttons and one contact block. Photographs are approximately 60% actual size.

★ ★

SQUARE D COMPANY

DETROIT • MILWAUKEE • LOS ANGELES

★ ★

NEW LINE OF REALLY OIL-TIGHT AND...

MUCH MORE COMPACT PUSH-BUTTONS

DESIGNED *Specifically* FOR MODERN MACHINE TOOL SERVICE!

HERE'S WHAT THIS NEW LINE WILL HAVE TO OFFER!

Designed and built to meet rigid industrial specifications and requirements, these new push-buttons will stand up under hard, rough usage.

They require much less panel and back-of-panel space than those of previous design. Mounting facilities, however, permit interchangeability with older types LO, PO and MO units, when desired.

Push-buttons will have a variety of contact arrangements including a two-pole double circuit design with 8 terminals. Two and three position selector switches with several contact arrangements as well as two-pole double throw selector switch units will be available.

New Start-Jog button will combine the functions of a start button and a Jog-Run selector switch in a single unit. Eliminates a push-button or selector switch on the control station and in many cases makes a relay on the control panel unnecessary.

Lockout latches and mushroom buttons will be available. Momentary contact push buttons may be made into maintained contact type with a special adapter. This can be done in the field without special tools.

Ask Your Square D Field Engineer

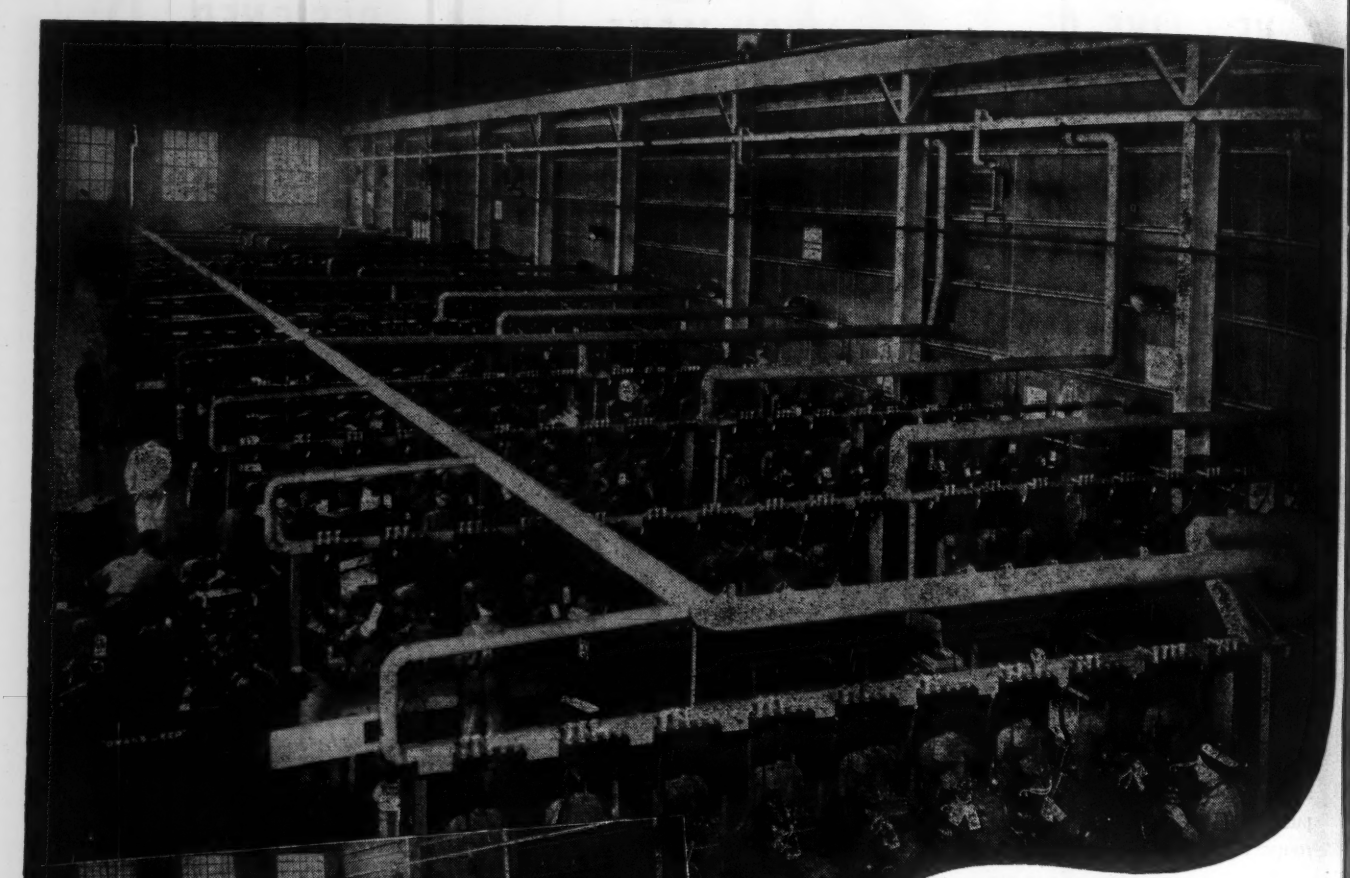
for more detailed information on this new, improved push-button line—scheduled for production the second quarter of 1945. Or write Industrial Controller Division, Square D Company, 4041 N. Richards Street, Milwaukee 12, Wisconsin.

Square D designed these new control units with the determination that they *must* be oil-tight and coolant-tight. The testing machine shown above has amply proven their ability to meet this primary requirement.

The testing machine pushes the button and releases it to simulate actual service. At the same time it bathes the push button in a continuous flow of liquid.

Millions of operations have been run using various cutting and grinding oils and coolants, and even water—yet these buttons have withstood them all without any leakage.

★ ★ ★ ★ ★ ★ ★



Here is One of Many Problems PENFLEX *Has Helped to Solve . . .*

Illustrated, Onan Generators on test in world's largest test rooms.

The Onan plant was one of the first to solve the problem of exhaust heat. They installed PENFLEX Flexible Metallic Exhaust Pipes to convey exhaust heat from generators on test to main distribution system where it is routed to other operations and re-used. A PENFLEX Flexible Metallic Exhaust is packed with each generator to be used wherever Onan sets are found.

Four-wall interlocking joint construction, flexibility, and insulation against vibration make PENFLEX suitable for such a job.

PENFLEX Flexible, All-Metal Hose or Tubing is also available for bilge ventilation, dust collection, coolant conveying, vibration isolation, hydraulic and air controls and many other applications.

Perhaps you, too, have a similar problem. If so, our Engineering Department will help you solve it.

PHOTOS COURTESY D. W. ONAN

PENFLEX METAL HOSE

PENNSYLVANIA FLEXIBLE METALLIC TUBING CO.

7219 Powers Lane, Philadelphia 42, Pa.

ESTABLISHED 1902

They're Going Overboard For Victory—Are YOU?

USE 8-POINT PLAN FOR AN OVERBOARD DRIVE IN THE 6th WAR LOAN!

NOV. 20th TO DEC. 16th

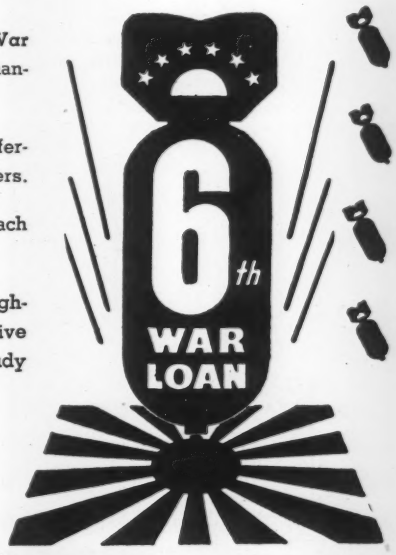
Our fighting men still have a long way to go! But—your plant-wide selling of the 6th can do much to shorten their embattled miles—lessen the price they so willingly pay for victory! Join the coast to coast parade of patriotic firms that are assuring an **"overboard" showing in the 6th** by following through on **every** point in the 8-Point Plan.

Start the ball rolling by appointing a **6th War Loan Bond Committee**, representing labor, management and other groups.

Carry on by selecting a **Team Captain**—preferably a returned veteran—for every 10 workers.

Right at the start, establish a **Quota** for each department—and every employee.

Arrange frequent **Meetings of Captains**, highlighting importance of their work—effective sales methods—and need for painstaking study of Treasury Booklet, Getting The Order.



Make definite **Assignments** to those best equipped to arrange music, speeches, rallies, competitive progress boards and meeting schedules.

Issue **Individual Pledge Cards**—made out in the name of each worker and providing for both cash and installment purchase.

Resolicit! This is the secret of "overboard" War Bond subscriptions. Your State Payroll Chairman has a special Resolicitation Plan for you to put into action near the end of the campaign.

Give generously of your **Advertising Space** to drive home the War Bond story.

The Treasury Department acknowledges with appreciation the publication of this message by

MACHINE DESIGN

★ *This is an official U. S. Treasury advertisement—prepared under auspices of Treasury Department and War Advertising Council* ★

This Governor-Controlled Oster Motor

Gives You the New Design and Operating Advantages of CONSTANT SPEED

Here is a new Oster development in a constant speed, governor-controlled motor that backs up your good judgment when you specify it for applications where constant speed is a necessity. This motor is now in production and deliveries can be made in the very near future. Here are the features that assure you of satisfaction:

Housing: Die cast aluminum end brackets. Mild steel field housing. Totally enclosed.

Finish: Black anodized end brackets. Cadmium plated field housing.

Weight: 15 Oz.

Bearings: Single shielded ball bearings, lubricated with a grease suitable for any specific application. Bearing housings fitted with steel inserts.

Windings & Insulation: Field coils and armature wound with a select grade of insulated copper wire and impregnated with a high quality heat and moisture resisting insulating varnish.

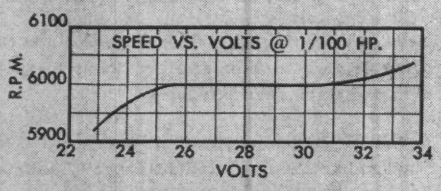
Brushes: Equipped with high grade metal graphite brushes. Beryllium copper brush springs.

Governor: Furnished with a centrifugal governor to maintain constant speed over a voltage range of 25 to 30 volts.

Temperature Rise: Maximum frame temperature rise at rated output will not exceed 55° C.

Modifications: Motors can be furnished with special shaft extensions, mounting arrangements, finishes, leads, etc. All modified units are considered special.

When designing your post-war product, consider this new Oster development in applications where constant speed is a nesessity...



Rating of Motor Type BSTG-1A-2

Horsepower—1/100 continuous duty

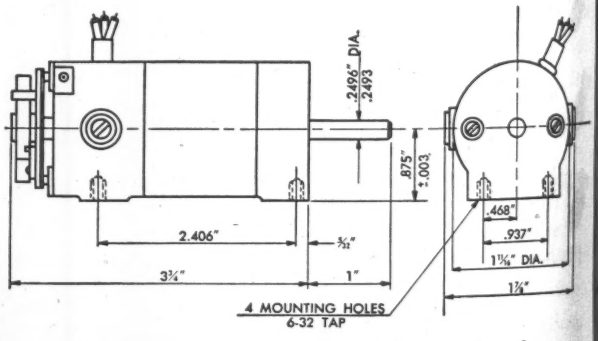
Speed—6000 R.P.M. ± 1%

Voltage—25-30 volts D.C.

Amps. input—.95

Starting Torque—300% of full load torque

• • •



Oster FRACTIONAL H.P. ELECTRIC MOTORS

Let us help you fit this and other Oster Motors to your requirements.

M-22

John Oster Manufacturing Co.

DEPARTMENT M-22 • RACINE, WISCONSIN

EASIER MACHINING

WHEN IT'S A SHENANGO-PENN BRONZE CENTRIFUGAL CASTING

USE Shenango-Penn centrifugally cast bronzes to lower your machining costs. Machining is easier, there is less metal to remove, production is faster—because our process develops such a fine, even grain structure. Castings are uniformly dense and strong, free of sand inclusions and other imperfections.

Due to superior values, Shenango-Penn castings are being used in large quantities in shipbuilding, aviation, ordnance and other war industries. As war needs slacken, centrifugally cast bronzes will be available for hundreds of peacetime applications, too—where rings, bushings, bearings and other tubular parts of better than average quality and durability are wanted.

Shenango-Penn castings are made in all bronzes and other non-ferrous and ferrous alloys. Cylinders and tubular bars can be cast with almost any wall thickness, from 2" to 26" O.D., up to 26 feet long. Supplied as rough castings, or machined to your specifications.

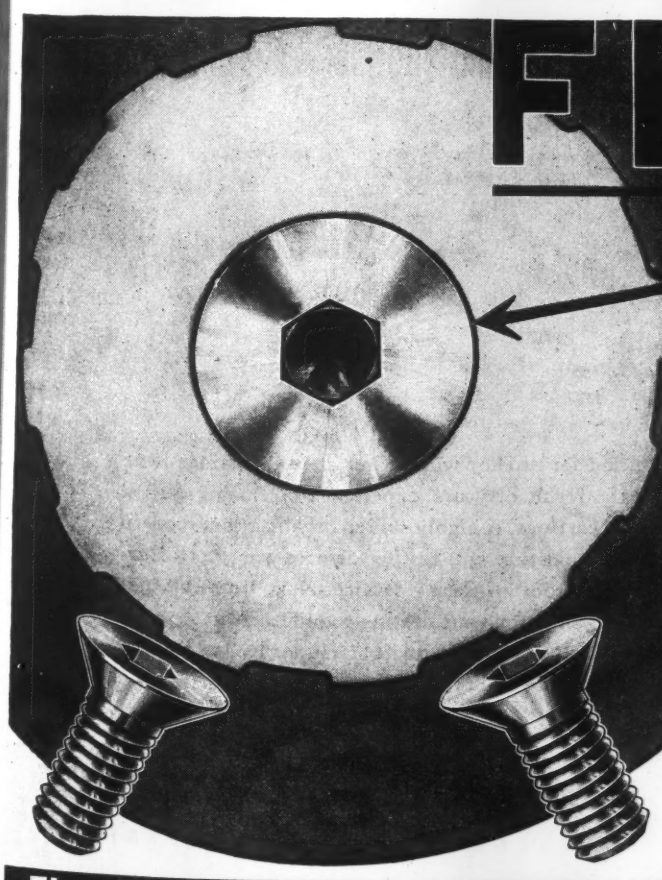
Ask for a free copy of our Bulletin 143

SHENANGO-PENN MOLD CO.

1245 WEST THIRD STREET • DOVER, OHIO

Executive Offices: PITTSBURGH, PA.

FLUSH!



ALLEN FLAT HEAD Cap Screws

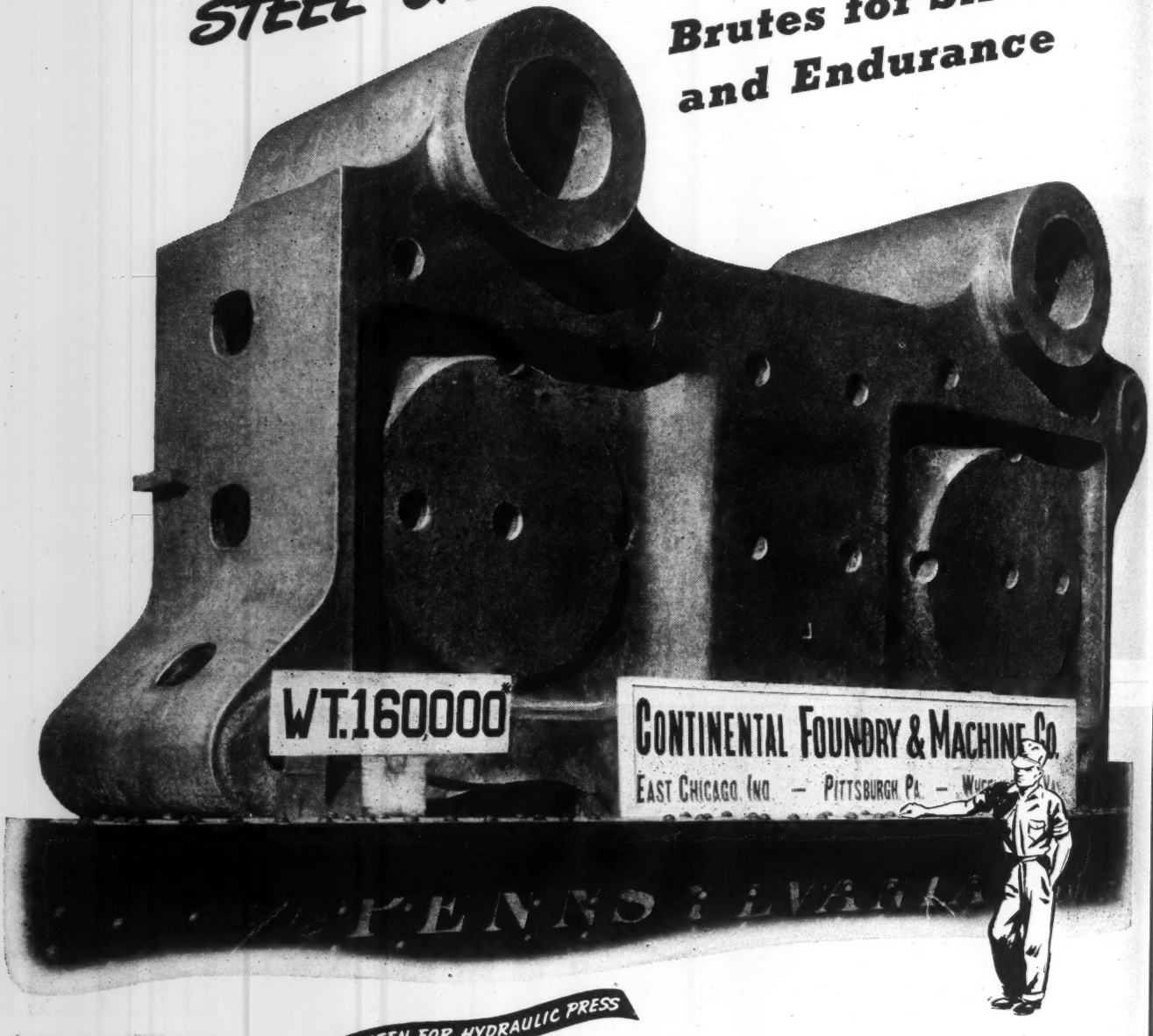
They set up in a counterbored hole more truly *flush* than any other type of hollow screw. The V-head fits the counterbore with complete *closed contact* all-round. This gives frictional holding-power and rigidity of grip... "Pressur-formd" of ALLENOY steel, with uncut metal fibres shaped to the head. Threads also *pressur-formd,* with tolerance held to a high Class 3 fit.

Obtainable as a part of the ALLEN Line from your local Industrial Distributor. *Ask for samples* and dimensional data.

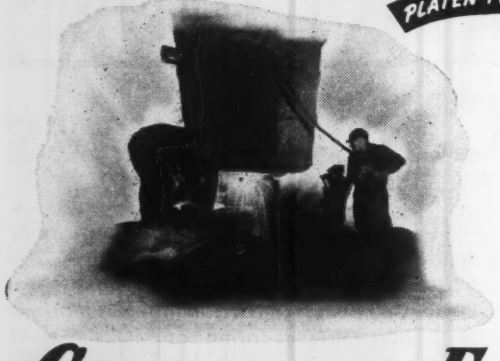
The Allen Mfg. Company ★ ALLEN ★ Hartford, Conn., U. S. A.

CONTINENTAL STEEL CASTINGS—

Brutes for Strength and Endurance



PLATEN FOR HYDRAULIC PRESS



The recognition for quality which Continental castings have achieved is the result of years' experience producing carbon and alloy steel castings. A highly skilled organization, modern shops, special inspection and testing devices are your assurance of the maximum in casting service. Next time call in a Continental engineer for your casting requirements.

Other Continental products include Rolls, Rolling Mill Equipment and Special Machinery.

CONTINENTAL FOUNDRY & MACHINE COMPANY

(FORMERLY CONTINENTAL ROLL & STEEL FOUNDRY COMPANY)

CHICAGO • PITTSBURGH

The Weight of Specialties Must Come Down

LIGHTWEIGHT ALUMINUM WILL HELP REVERSE THE UPWARD TREND

Upgrading the luxuries provided passengers has kept car weights at a nearly constant, high level throughout the years. Specialties added to comfort-condition coaches have grown steadily in size and number. Contrariwise, car bodies have been reduced to almost one-half their weight of 1906.

Alcoa Aluminum Alloys have been important contributors to the car shell weight-reduction program. They will do the same thing for specialties.

In addition to this weight-saving ability, aluminum alloys offer high strength, sturdiness and dependability. You know the miracles aluminum has performed in the country's war effort. Aluminum provides high electrical and heat conductivity. It is highly resistant to corrosion. Because of the many attractive, durable finishes possible with aluminum, it lends itself well to the designer who is seeking ways of achieving unusual and interesting effects.

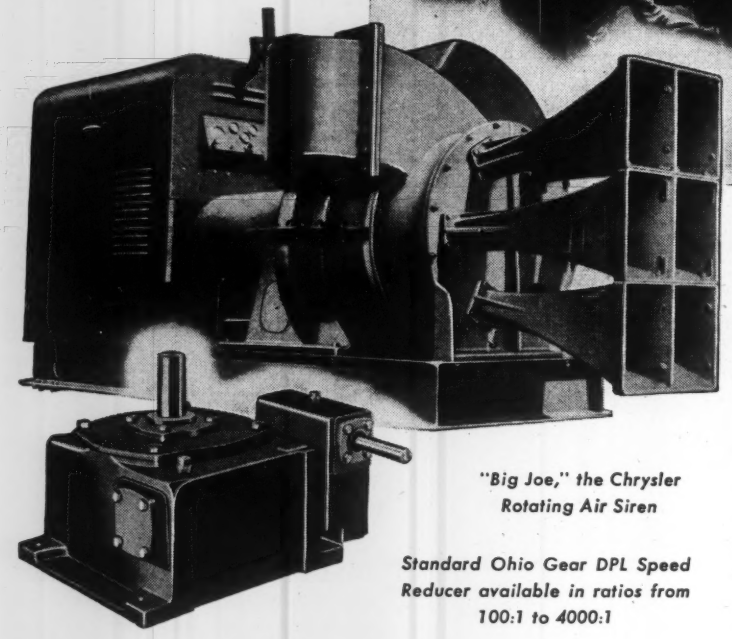
Aluminum is available, with W.P.B. approval, for other-than-war purposes. Alcoa representatives will gladly assist in determining how and where you can use it. Write ALUMINUM COMPANY OF AMERICA, 1940 Gulf Bldg., Pittsburgh 19, Penna.

ALCOA ALUMINUM

REG. U. S. PAT. OFF.

OHIO SPEED REDUCER

HELPS BLAST HOLES IN ENGLAND'S FOG!



"Big Joe," the Chrysler Rotating Air Siren

Standard Ohio Gear DPL Speed Reducer available in ratios from 100:1 to 4000:1

Maybe you've read about "Big Joe," the loudest mechanical sound in the world. Designed and built by Chrysler Corporation as an air raid siren, Big Joe has turned out to be the airmen's friend. Now, mounted at hundreds of air fields, that terrific voice actually blasts holes through fog.

An important part of Big Joe's action is to rotate slowly, to throw its sound in every direction. This rotary motion must be smooth, steady, dependable. The speed of the 3200 RPM Chrysler engine (stepped up to 440 RPM at the blower) must be reduced to as little as ½ RPM at the turntable. When Chrysler engineers looked for a compact, efficient speed reduction method, they found it, designed and ready for use, in a standard Ohio Gear Reducer.

So Ohio Gear Reducer DPL 1 was adopted as standard equipment and has been giving a satisfactory account of itself in Big Joe operations ever since.

Helping blast holes in fog is another Ohio Gear war job and another indication of the possibilities Ohio Gears and Reducers may hold for peacetime products.

THE OHIO GEAR COMPANY

1338 EAST 179th STREET — CLEVELAND, OHIO

Representatives

*NEW YORK 13, N. Y.
Patron Transmission Co.
129 Grand Street

NEW ENGLAND
George G. Pragst
P. O. Box 995, Pawtucket, R. I.

*LOS ANGELES, CALIF.
J. W. Minder Chain & Gear Co.
927 Santa Fe Avenue

GRAND RAPIDS 8, MICH.
W. H. Slaughter
3753 Division Ave. S.

*PITTSBURGH, PA.
Standard Machinists Supply Co.
South 2nd and McKean Street

DETROIT 2, MICH.
George P. Coulter
322 Curtiss Building

*MINNEAPOLIS, MINN.
Industrial Supply Co.
717 S. Eighth Street

BUFFALO 16, N. Y.
F. E. Allen
1315½ Hertel Ave., Room 9

*KANSAS CITY, MO.
Kansas City Rubber & Belting Co.
712 Delaware Street

*SAN FRANCISCO, CALIF.
Adam-Hill Co.
244-246 Ninth St.

LOUISVILLE, KY.
Alfred Halliday, 330 Starks Bldg.

INDIANAPOLIS 4, IND.
A. R. Young
635 N. Pennsylvania St.

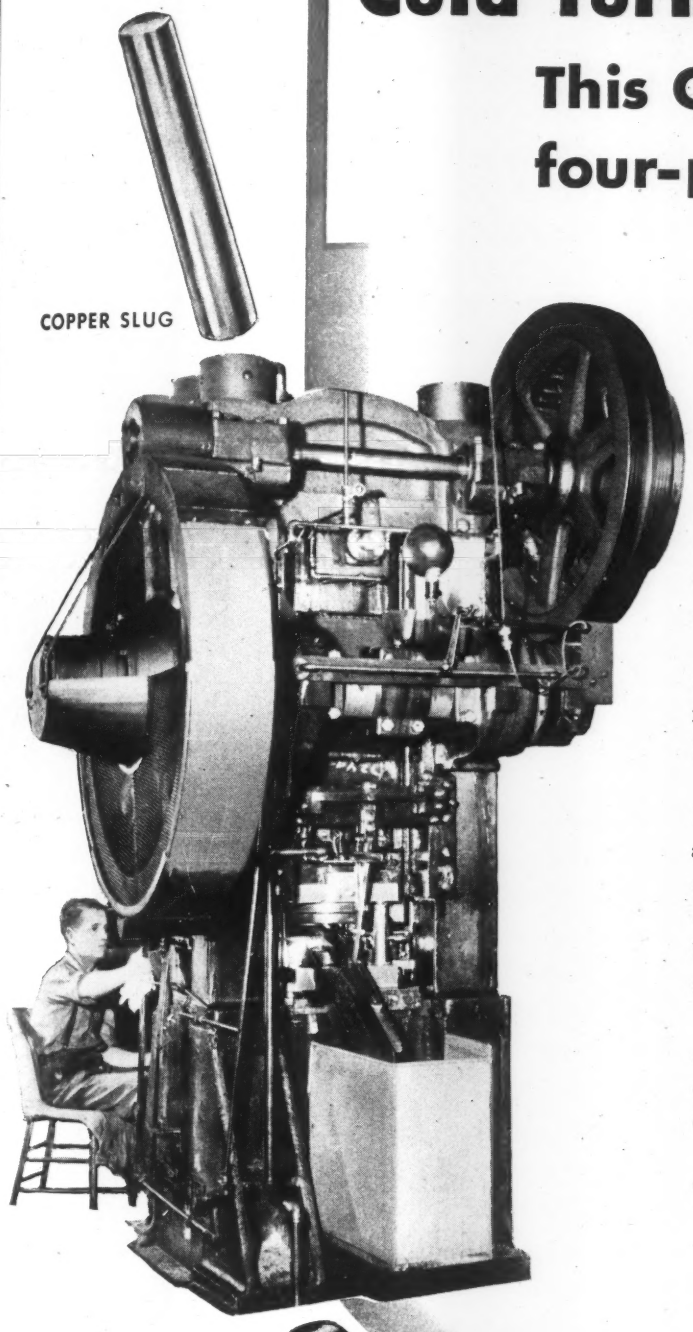
ST. LOUIS, MO.
St. Louis Tool Co.
2319 N. Ninth Street

Stocks carried.

OHIO GEARS

Cold formed in one stroke

This Copper cap replaces four-piece Gillette assembly



Caps for Gillette Razors were formerly made in four pieces; the curved plate with a centered hole, a threaded center pin to which the handle was attached, and two studs for holding the blade in position. Furthermore, assembling the cap was a slow and tedious operation.

But things are different now—a faster, more accurate and economical method has been devised. Because of the excellent cold working properties of copper, thousands of caps are now produced daily . . . formed in one piece . . . in 400-ton presses.

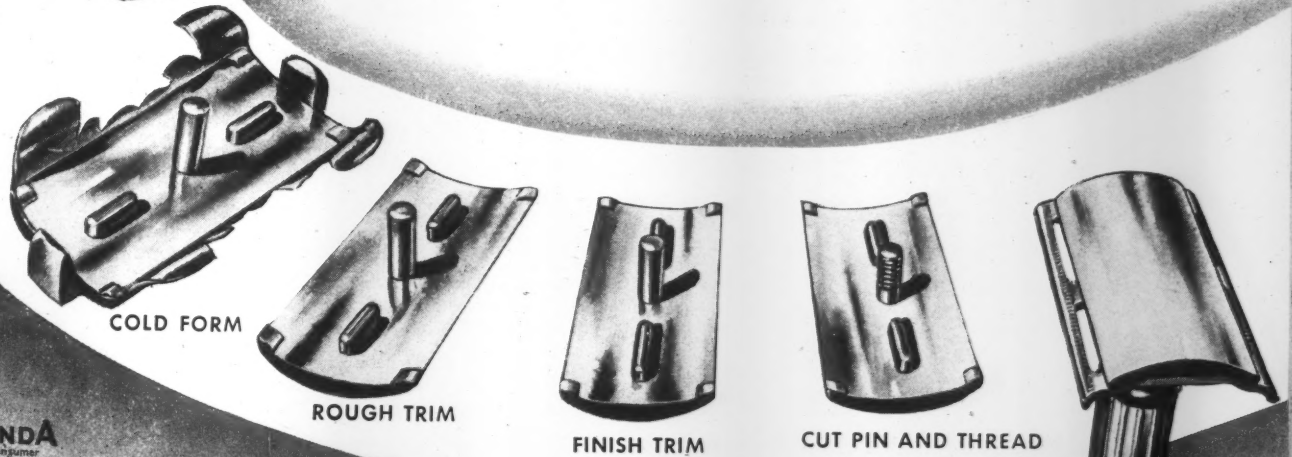
Coils of Anaconda Copper Rod .320″ diameter, are cut into slugs 1¾″ long and are magazine-fed into the press. The cold formed part, with flash attached, is illustrated below in actual size. The sequence of finishing operations is also shown.

RESULTS: *1.* Production has been speeded up about 200%. *2.* The one-piece construction eliminates the possibility of assembled parts working loose. *3.* Extremely accurate dimensions, necessary for blade alignment, are maintained without difficulty. And, as nothing serves like copper as a rust-free base metal for applied finishes, these Gillette Razor parts are readily plated with gold, nickel, chromium—or as desired.

Copper, or one of its many workable alloys, may be the answer to a similar job which you may consider especially difficult. Your inquiry will be given every consideration by our Technical Department.

THE AMERICAN BRASS COMPANY

General Offices: Waterbury 88, Connecticut
Subsidiary of Anaconda Copper Mining Company
In Canada: ANACONDA AMERICAN BRASS LTD., *New Toronto, Ont.*



ANACONDA
from mine to consumer

Anaconda Copper & Copper Alloys

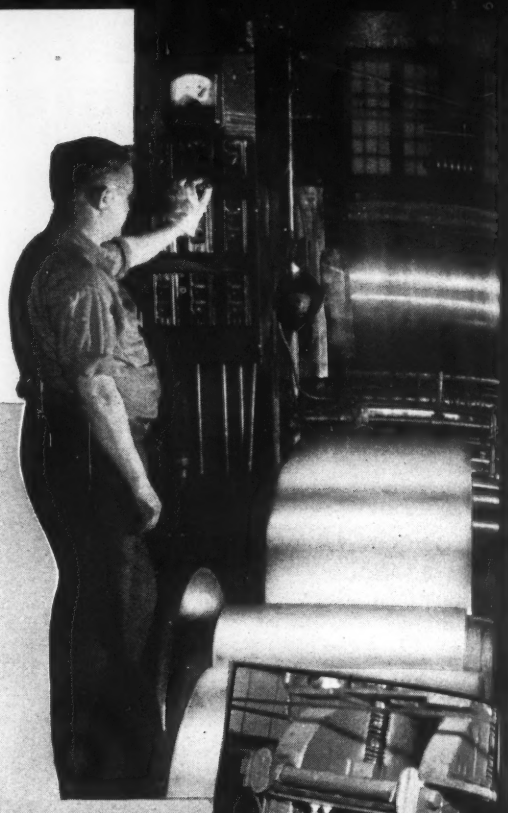
It takes more than Modern Equipment to meet ALL Sheet Metal Requirements

Production men know that low costs and smooth-flowing manufacturing operations go hand in hand when materials are consistently uniform—when sheet after sheet or coil after coil have the same fabricating characteristics.

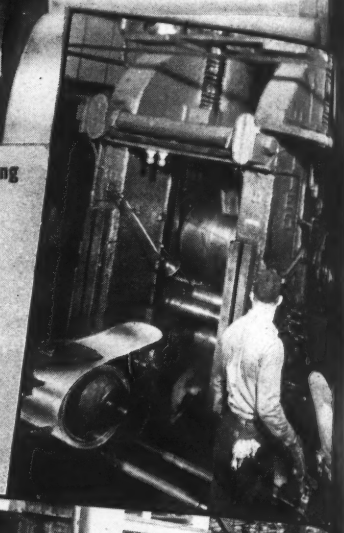
But there's more to the making of such metal than modern equipment—important as that is. To produce brass plate, sheet or strip that meets ALL requirements calls for strict technical control over every step of production, from the casting shop to the last pass on the finishing rolls. For only in this way can the composition, grain size, temper and finish be controlled to obtain the best combination of properties for spinning, stamping, deep drawing or other fabricating operations.

In all probability, much time was devoted to the design and development of your sheet metal products—and also considerable money in tooling up for their production. So when you order copper, brass, bronze, or nickel silver, take the added precaution of specifying "ANACONDA". This is your assurance that the product is made by THE AMERICAN BRASS COMPANY to consistently uniform specifications and tolerances.

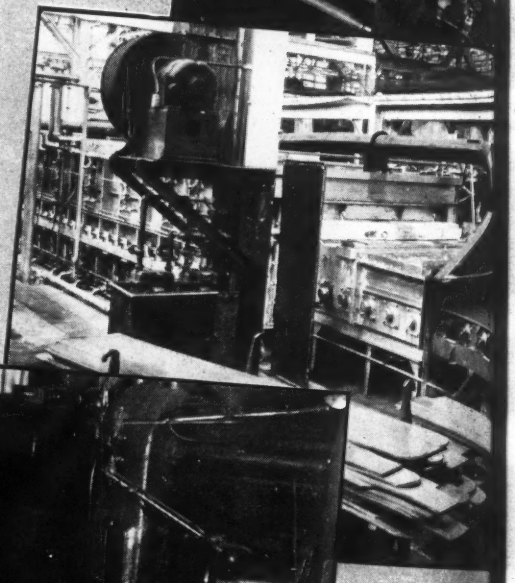
44210



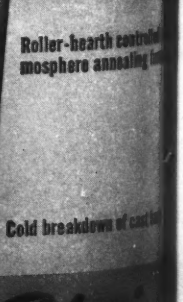
Cold rundown rolling of coils



Second operation on four-high roll



Casting bars in water-cooled mold



Roller-hearth control... mosphere annealing...

Cold breakdown of cast...

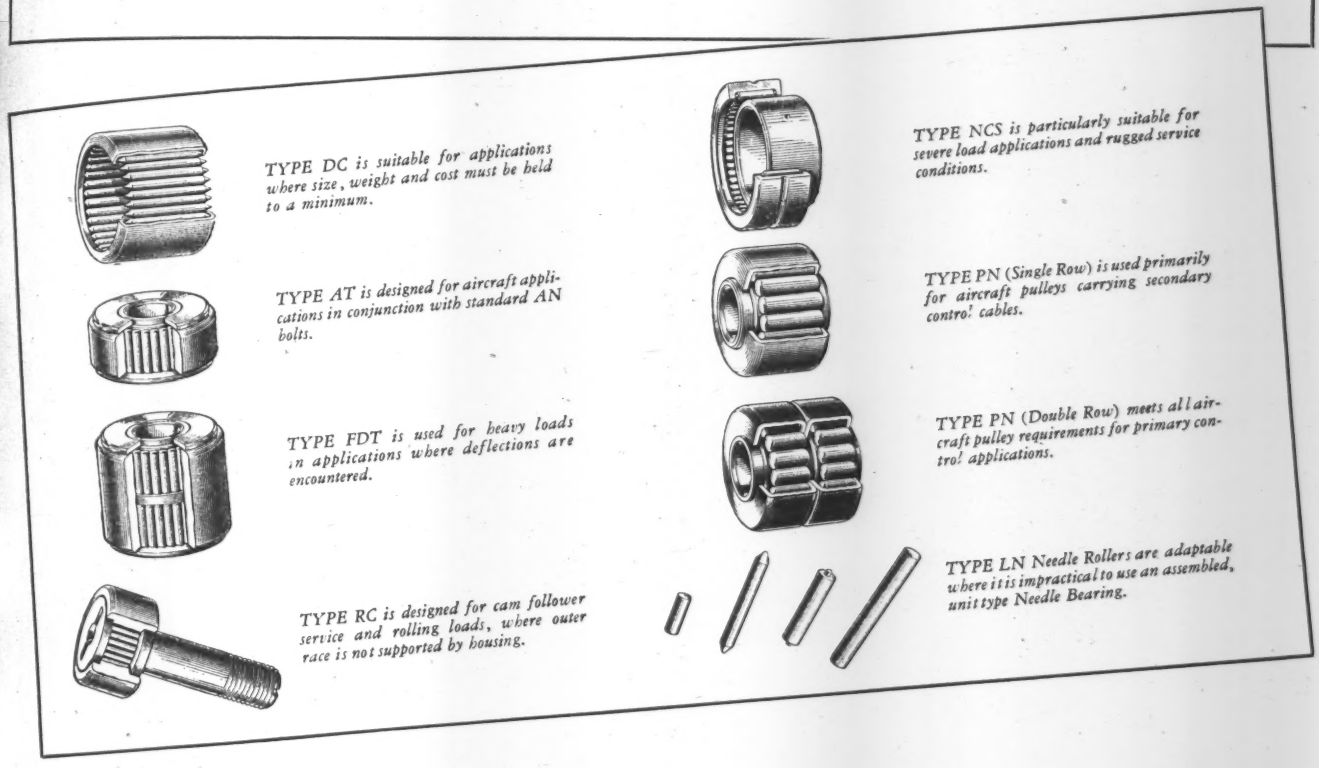
THE AMERICAN BRASS COMPANY

ANACONDA
from mine to consumer

General Offices: Waterbury 88, Connecticut
Subsidiary of Anaconda Copper Mining Company
In Canada: ANACONDA AMERICAN BRASS LTD., *New Toronto, Ont.*

Anaconda Plate, Sheet and Strip

One of these Needle Bearings May Solve a Design Problem for You...



TYPE DC is suitable for applications where size, weight and cost must be held to a minimum.

TYPE AT is designed for aircraft applications in conjunction with standard AN bolts.

TYPE FDT is used for heavy loads in applications where deflections are encountered.

TYPE RC is designed for cam follower service and rolling loads, where outer race is not supported by housing.

TYPE NCS is particularly suitable for severe load applications and rugged service conditions.

TYPE PN (Single Row) is used primarily for aircraft pulleys carrying secondary control cables.

TYPE PN (Double Row) meets all aircraft pulley requirements for primary control applications.

TYPE LN Needle Rollers are adaptable where it is impractical to use an assembled, unit type Needle Bearing.

It may not have occured to you that there are so many *different* types of Needle Bearings—or that the completeness of the line of these modern, antifriction bearings makes them adaptable to many design requirements.

Pictured above are eight different types—all different in design yet employing the same basic design principle of a full complement of small diameter needle rollers. Each is engineered for a particular task—or combination of design requirements. Individually each offers the same characteristic advantages of compact design, small size, light weight, high capacity, efficient lubrication and low cost.

The result is that in almost any application where Torrington Needle Bearings are employed, the design problem is simplified; operating efficiency and service life are increased; manufacturing costs are reduced, and sales features are added.

Investigate for yourself how these advantages can be of assistance in your product planning. The Torrington Needle Bearing Catalog 30-A gives complete information, and our engineering staff is ready to help you with any specific design requirement.

THE TORRINGTON COMPANY

Established 1866 • Torrington, Conn. • South Bend 21, Ind.

"Makers of Needle Bearings and Needle Bearing Rollers"

New York Boston Philadelphia
Detroit Cleveland Seattle
San Francisco Chicago Los Angeles
Toronto London, England

"LET'S GO! U.S.A. KEEP 'EM FLYING"

TORRINGTON

NEEDLE BEARINGS

PROVEN on every Battlefront

NOW READY for Your HYDRAULIC EQUIPMENT

Greer HYDRAULIC ACCUMULATORS

Here is a simple, small, low-cost accumulator that sets new standards of performance. Greer Hydraulic Accumulators, battle-tested under the severest conditions on military equipment, are now available for your hydraulic system.

Reliable—The cross-section shows the simplicity of construction which accounts for the reliability and low cost of Greer Hydraulic Accumulators. The one-piece chrome-molybdenum seamless steel shell has a completely enclosed synthetic rubber bag with an integrally molded air valve. No welds. No joints. No packing. No air leaks.

Operation—The accumulator is precharged from the regular shop air supply through an inexpensive booster pump, just like a pneumatic tire. Recharging is necessary only every three or four months.

Sizes, Proportions—Standard sizes range from 4-1/8 D by 8-1/16 long for the 1/3 gallon accumulator, to 12-3/4 D by 52-5/8 long for the 25 gallon accumulator. Operating pressures are from 1000 to 3000 psi, depending upon capacity. For larger capacities, multiples of standard sizes may be hooked up in parallel. Shell proportions and shapes may be varied from standard to suit any condition.

Low Cost—The low cost of Greer Hydraulic Accumulators permits the application of hydraulics in highly competitive portable and stationary equipment.

Engineering Assistance—Our hydraulic engineers will gladly help you with your problem. Write.

HYDRAULIC POWER

GREER

GREER PRODUCTS CORPORATION

39 West 60th Street, New York 23, N. Y.

• Right in the "center of things" if your design calls for light weight, strength and durability. If you have designs which Magnesium Castings might improve, Superior engineers will be glad to help you work them out. Write today. No obligation.

Informative Booklet "Facts for the Designer" Available Upon Request

Superior Bearing Bronze Co., Inc.

MAGNESIUM DIVISION • 151 BANKER ST. • BROOKLYN 22, N. Y.

MAGNESIUM CASTINGS TO MEET U. S. ARMY & NAVY SPECIFICATIONS

Girl in bomber fuselage is tightening one of the hundreds of wire harness bands used on each Boeing B-29 Superfortress. Bands are supplied by United-Carr Fastener Corp. Each band is lined with cellular rubber, produced by Sponge Rubber Products Co., to cushion, insulate and prevent chafing. Parts are small – but they do a big job in protecting wiring against vibration of four 2200 h.p. motors and the recoil of Superfortress guns.

Available NOW for Industrial Production

We compound cellular rubber to your specifications – have developed methods of controlling resiliency, cell structure, tensile strength, and resistance to heat, cold, moisture, oils, acids, corrosive vapors, and abrasion. If sheet material does not solve your problem of cushioning, sealing, sound deadening, insulating, or vibration dampening, we can supply you with tubing, cord, slabs, strips, or molded parts. Describe your requirements; our technical staff will tell you frankly whether or not cellular rubber will do your job.

THE RUBBER COLLAR THAT TOOK THE 'RUB' OUT OF WIRE HARNESS

. . . A lesson in post-war progress from a Boeing Superfortress

The tiny strips of cellular rubber that cushion the hangers for wires in the B-29 Superfortress cost just a few pennies. But what a man-size job they do! They soak up vibration . . . prevent chafing . . . keep wires in condition to "keep 'em flying"!

Wherever there is a danger of vibration – in an automobile, an airplane, a railroad train, a machine tool, a home appliance – *any* motor-driven piece of equipment – similar applications of cellular rubber can lengthen the life of equipment; help assure trouble-free operation.

Two Basic Types Available

Our organization, with 21 years' experience compounding sponge rubber (Spongex*) also produces another basic type of *cellular rubber* – Cell-tite*. In Spongex, the most familiar type of this material, the cells inter-connect. In Cell-tite the cells are individual, separate, filled with inert gases.

Consult us *now* if you need any variety of cellular rubber. We are able and ready to help you solve any problem of sealing, cushioning, vibration dampening, sound deadening, insulating, and have ample production facilities to meet your present and post-war needs.

* Trade Mark Registered

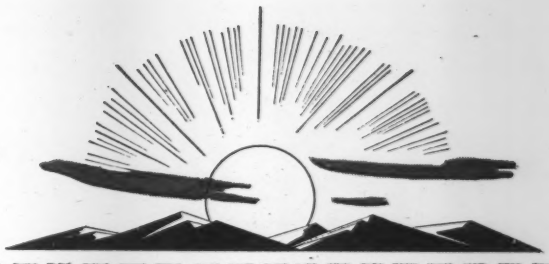
Sponge Rubber Products Co.

122 Derby Place, Shelton, Conn. • Plants in Derby and Shelton, Conn.

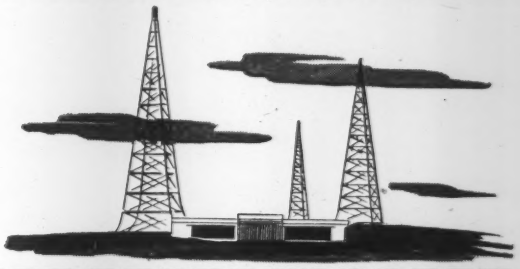
Sales Offices: NEW YORK • CHICAGO • WASHINGTON • DETROIT

World's Largest Manufacturer of Cellular Rubber Products

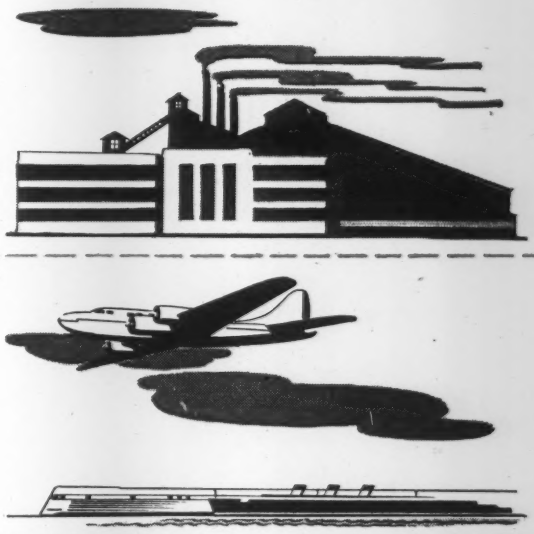
A Great Electronic Day...



for Communications

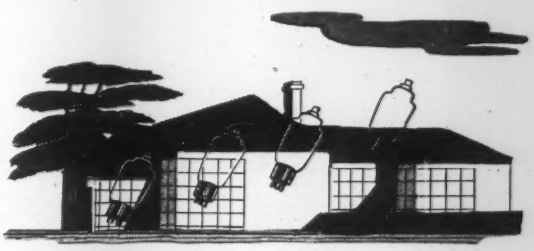


for Industry



for Transportation

for Home



Raytheon is proud of its contributions in the development of new electronic tubes and complete electronic equipment for the Armed Forces. Proud of the trust the military has placed in our designs, engineering and manufacturing abilities.

When war ends, Raytheon's wartime experience, research facilities, engineering and the production skills of over 16,000 men and women will be turned to peacetime electronics. Then you'll hear about and see Raytheon Electronic Equipment that will provide untold benefits in all phases of electronics. In the coming Age of Electronics . . . LOOK to Raytheon for complete electronic equipment and electronic tubes.

Tune in the Raytheon radio program: "MEET YOUR NAVY," every Saturday night on the entire Blue Network. Consult your local newspaper for time and station.

R RAYTHEON
MANUFACTURING COMPANY
Newton and Waltham, Massachusetts

Devoted to research and manufacture of complete electronic equipment; receiving, transmitting and hearing aid tubes; transformers; and voltage stabilizers.

Scully-Jones Tap Chucks

STYLE "A" TAP CHUCKS have five big advantages for driving taps:

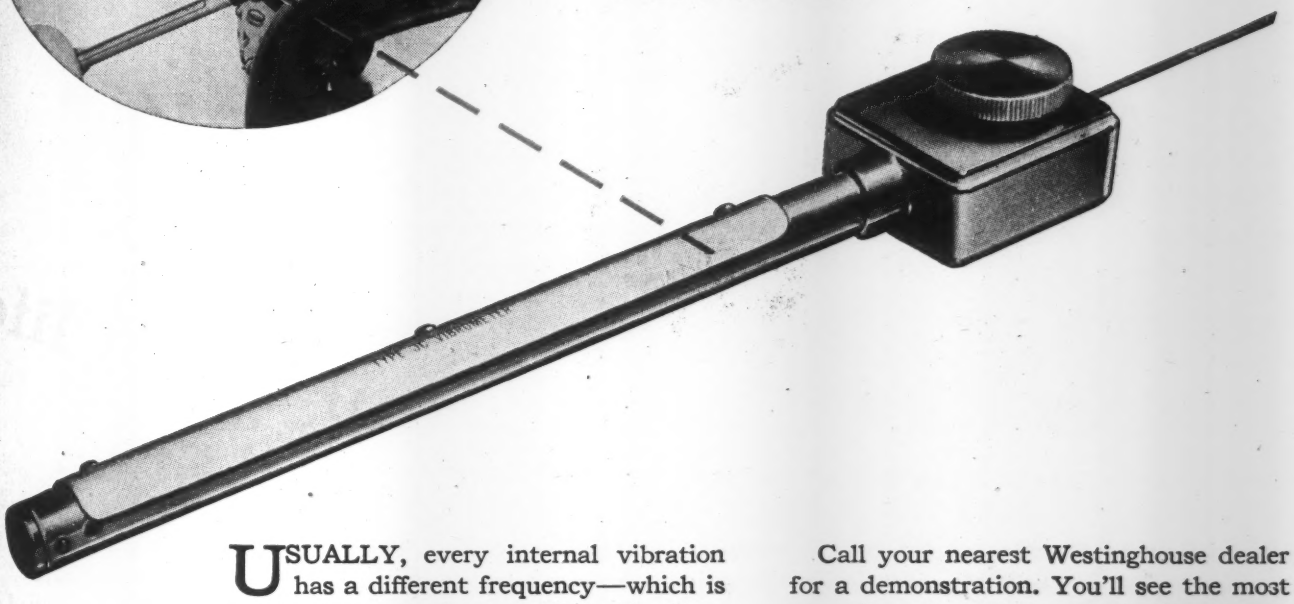
1. Drive by the square—giving a positive drive.
2. Centers by the shank—for correct alignment.
3. Spring collet action—for locking tap in chuck.
4. Four point bearing—giving collet action.
5. A tapered shank—fits any MORSE TAPER HOLE.

RECOMMENDED FOR MAXIMUM RIGIDITY AND CONCENTRICITY IN TAPPING OPERATIONS

SCULLY-JONES AND COMPANY

1901 SO. ROCKWELL STREET • CHICAGO, ILLINOIS. U.S.A.

this eight-ounce detective catches each separate vibration



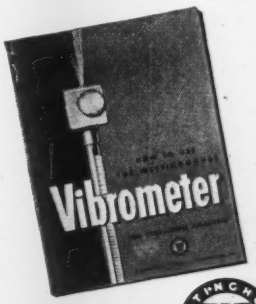
USUALLY, every internal vibration has a different frequency—which is its identifying trade-mark. Nab this vibration at its source and the rest is easy—the cure will suggest itself.

The new Westinghouse Vibrometer is the quickest, simplest, most economical (only $92!) instrument you can get for the job. Just hold it against the vibrating machine and turn the knob through its range to vary the length of the reed. This reed will vibrate in unison with *each separate* vibration in the machine—and you can read the frequency *directly* from the scale on the other end.

Follow this procedure for each machine, tracing the flow of power from the prime mover, and you'll be able to identify each vibration *positively*—at its source. The Vibrometer automatically breaks complex vibrations down to their component individual vibrations — no more interpolation of vibration wave forms is necessary.

All vibration frequencies between 500 and 20,000 cycles a minute register directly on the Vibrometer scale—and harmonics of a vibration will not register unless they're actually present in the machine.

Call your nearest Westinghouse dealer for a demonstration. You'll see the most versatile vibration analysis instrument available today—small enough and light enough for use *anywhere*, yet sensitive and accurate enough for every normal need. Westinghouse Electric & Mfg. Co., P. O. Box 868, Pittsburgh 30, Pa. J-08093

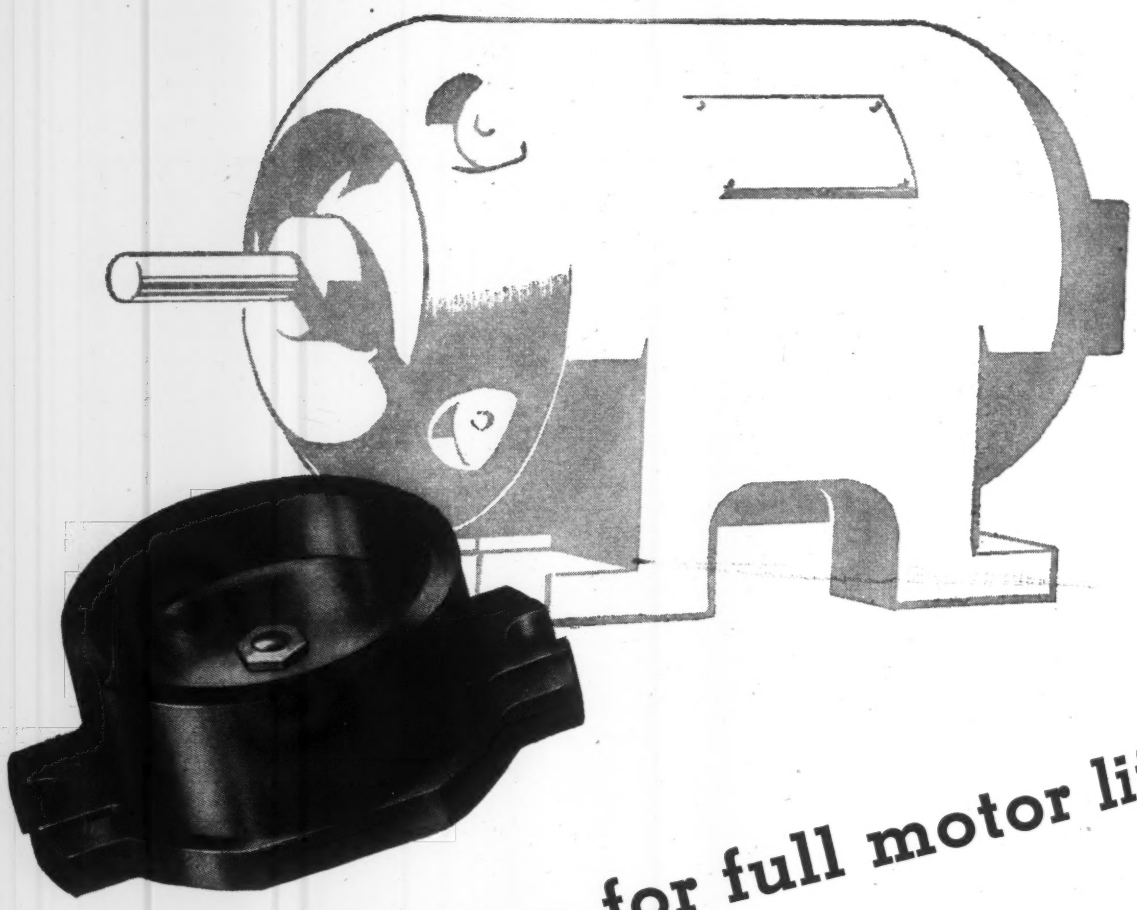


What the Vibrometer does —how it operates, is described in detail in this new 32-page pocket-size manual, B-3414. Write for your free copy today.

Westinghouse

Vibration Analysis

Instruments



Right Combination for full motor life

Because Klixon Motor Protectors are matched and built into the motors by the motor builder, they give you a tested and proven combination that assures full motor life.

The Klixon Protector provides accurate motor overheat protection. It prevents motors from becoming dangerously hot and burning out . . . yet always permits the motor to operate at maximum capacity.

Actuated by a scientifically calibrated thermostatic disc that outlasts the motor, Klixon Protectors cut the power "off" should the motor reach a dangerous operating temperature. When the motor cools to a safe level, the protector clicks the power "on" again, either automatically or by manual reset depending on the type of protector you specify.

Why put up with motor burnouts when you can buy Klixon Protected motors for a small amount extra? They're available for A.C. motors all sizes; D.C. motors up to 30 volts. Play safe! Specify built-in Klixon Protectors with every motor you buy.

KLIXON MOTOR PROTECTORS

SPENCER THERMOSTAT CO., ATTLEBORO, MASSACHUSETTS

VARD ACME GAGES

VARD is making Acme Thread Gages in plugs (tape lock, tri-lock and annular types), rings, and r thread snap gages (John-Sons type). Sizes produc run from ¼-in. diameter to 12-in. Gaging mer bers are made of selected tool steels. They are har ened in atmospheric controlled furnaces. All gagi surfaces are ground and finished to the same acc racy and tolerances as V threads. All VARD gag will meet the specifications as set up by Scre Thread Standards for Federal Services.

We can handle orders in quantity and guarant quick service (by present day standards).

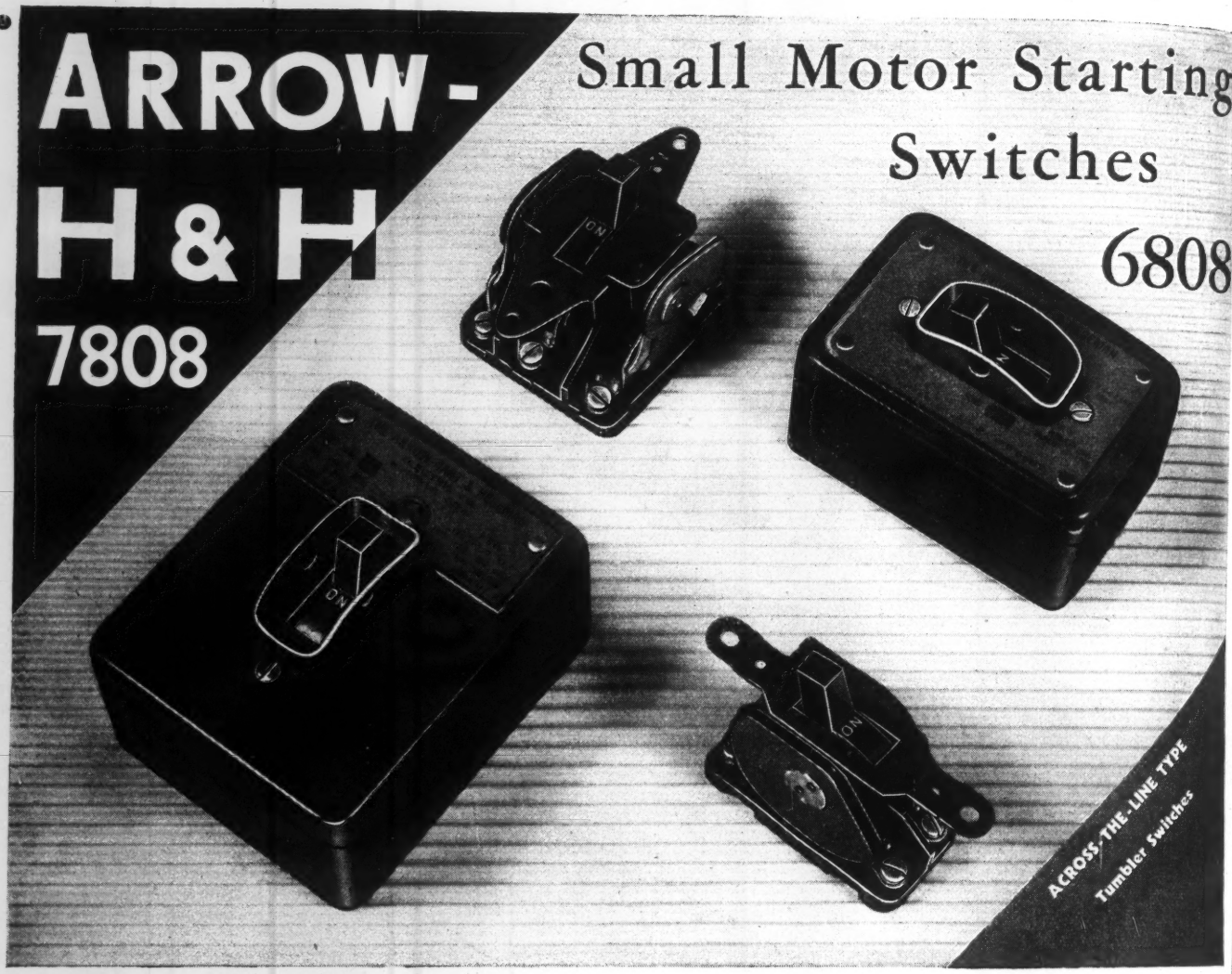
ARMY E NAVY

VARD INC.

PASADENA 8, CALIF.

ARROW-H&H 7808

Small Motor Starting Switches 6808



ACROSS-THE-LINE TYPE without overload protection

Everywhere relied upon to give positive control of motors; especially suitable for oil burners, refrigerators, motor-driven machinery and lighting loads.

These switches have rugged, durable mechanisms built to perform with the sturdy integrity characteristic of Arrow-H&H Lines. Bakelite arc snuffers increase breaking capacity; kick-off release mechanically starts the switch blades in motion and prevents sticking; extra-heavy blades and contact jaws increase current-carrying capacity.

Different styles of mounting are supplied for a wide range of machine-design requirements. Separate switch units are available for installations in switch housings built into motor-driven machinery.

No. 6808 (upper and lower right) is a double-pole switch for single phase motors; No. 7808 (upper and lower left) is 3-pole for 3-phase jobs. Also, the line includes 3-way, 4-pole and 2-speed reversing switches. All have horsepower ratings... Everything you may need in this line will be found in Motor Starting Switch Catalog No. 9-M — on request.

INDUSTRIAL CONTROL DIVISION

THE ARROW-HART & HEGEMAN ELECTRIC COMPANY, HARTFORD, CONN., U.S.A.

Close Tolerances in Light Gauge Aluminum Stampings

Stamping 100,000 intricate parts a month for Airborne Command radio sets is definitely a job for a plant with unusual facilities and thorough experience. All holes in these parts must be held to very close tolerances to prevent rattle under severe vibration. The small section shown is stamped from .020″ aluminum 52S. All corners are accurately and smoothly rounded without cracking.

Why not investigate Presteel possibilities for lowering costs and improving production on your own products by the use of metal stampings? Mail samples or prints to

WORCESTER PRESSED STEEL CO.

312 Barber Avenue, Worcester 6, Mass.

ALLOY STEELS AND OTHER METALS COLD FASHIONED SINCE 1883

Jones

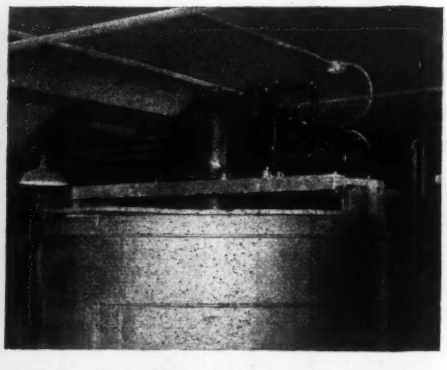
WORM-HELICAL SPEED REDUCERS

—for Vertical Shaft Drives

THESE machines fill a long felt need for double reduction units of the fully enclosed type to be used for agitators, mixers, ore roasters, bending rolls, etc., requiring a vertical shaft drive. Built in standard ratios in various types of assemblies ranging from 40 to 1 to 250 to 1 for all common motor speeds and a wide range of horsepower ratings.

Jones Bulletin No. 75 covers complete details on these Worm-Helical Speed Reducers, with rating tables, dimension diagrams, torque charts and other application information. We shall be pleased to send you a copy.

● Jones Worm-Helical Speed Reducer on ore roaster with section of dust guard removed to show final gear reduction.



● Jones Worm-Helical Speed Reducer driving a lacquer agitator. A simple design prevents leakage of oil along the vertical low speed shaft.

● Jones Worm-Helical Speed Reducer on a paper mill agitator drive.

W. A. JONES FOUNDRY & MACHINE CO., 4413 Roosevelt Road, Chicago 24, Illinois

LICKS CORROSION

SALTS

STEAM

COREX

Plastic Armor

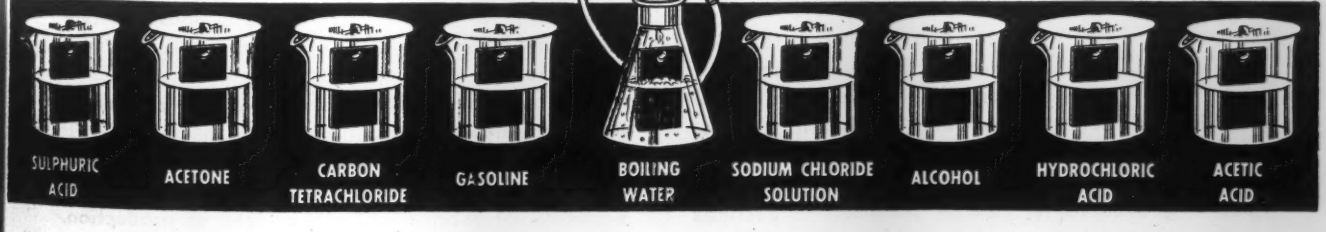
SOLVENTS

ACIDS

COREX is an organic finish applied to metal by dip or spray, giving it an enduring protective armor against corrosion by acids, salt spray, humidity, steam and other demons of destruction.

Products coated with COREX have been subjected to corrosive liquids and fumes without deterioration for over 10,000 hours — more than a year.

Available clear and in colors for industrial applications.



Send for our Research Laboratory Release — Technical Bulletin M

STANDARD VARNISH WORKS

2600 RICHMOND TERRACE
STATEN ISLAND, N. Y.

2600 FEDERAL STREET
CHICAGO, ILLINOIS

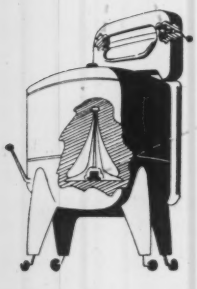
SINCE 1870

KEYSTONE

D-10

THE TRUE OILLESS BEARING MATERIAL

For bearing applications in the many new and improved post-war products, where no fluid lubricant can be used, we recommend D-10 "A True Oilless Bearing Material." A development of Keystone Carbon Company, D-10 is a combination of brass and fine graphite processed by powder metallurgy.



A typical application is in washing machines where it eliminates smudging of clothes usually encountered with other lubricants. D-10 provides its own lubricant by spreading a thin, even film of graphite between the shaft and the bearing, reducing friction to a minimum. The excellent heat dissipating qualities of the brass carries off what little heat is generated. It can be installed in castings prior to their painting and drying because the heat necessary for drying does not affect D-10.

OPERATING TEMPERATURES of D-10 range from −69°F to +800°F. D-10 remains stable at any temperature point between the minimum or maximum, and does not lose its bearing characteristics. It is ideal for use at temperatures where ordinary lubricants break down.

ELECTRICAL CHARACTERISTICS are excellent, enabling it to carry current with the least amount of contact drop.

IN VARIOUS LIQUIDS such as water, gasoline and other fluids where the bearing must operate under immersion are also successful applications for this material.

TENSILE STRENGTH of over 18,000 p.s.i. allows it to carry heavy loads.

As D-10 is a product of powder metallurgy, it also has the many advantages of this process, such as economy of fabrication, higher rate of production, closer tolerances, etc. Our engineers will be pleased to assist you with your bearing problems.

Write for details.

KEYSTONE CARBON COMPANY, INC.

Manufacturers of Precision Molded Products

1935 STATE ST., SAINT MARYS, PENNA.

Back of this Landing was

Production Control!

On Thousands of Machines Producing Supplies, Performance Is Measured by Stewart-Warner Industrial Tachometers

GETTING the men, machines and supplies to a beachhead calls for split-second timing. Back of America's ability to do this job are machines under CONTROL to split-second schedules in hundreds of factories.

On thousands of machines producing supplies and weapons, CONTROL is written on the dials of Stewart-Warner Industrial Tachometers.

Leading designers now specify these instruments to measure performance on any machine where output is related to machine shaft speed. This assures most efficient operating speed, holds quality to set standards, cuts unit costs, synchronizes machines with assembly lines, adds to machine life, helps meet quotas and speeded-up schedules.

Regardless of what you make or whether your machines are new or old, it's easy to add the CONTROL of Stewart-Warner Tachometers. Write for complete information and name of Stewart-Warner distributor.

NEW! Stewart-Warner WARNING SWITCH ... the "Motor Guardian"

Shown ½ Size

● Fastens in the motor block and warns of oil pressure or engine temperature danger point. Can be set at any specified danger point to close circuit to a warning light, or buzzer or to cut off motor ignition. This switch is actually a "motor guardian"—protects against bearing failure due to breakdown of either the lubricating or cooling system. Write today for complete information.

Write for FREE Catalog on Industrial Instruments

STEWART-WARNER

INDUSTRIAL TACHOMETERS

1804 Diversey Parkway, Chicago 14, Illinois

Another Product of STEWART WARNER

ASCO COMPLEMENTS THE CONTROLS

1 **Askania Hydraulic Reversal System controls the reversing cycle of an open hearth furnace**

2 **ASCO Solenoid Valves control the flow of hydraulic fluid to the Askania reversal valves**

NO better example of controlled mechanical operation can be found than in the Askania Hydraulic System of open hearth furnace reversal. These reversal valves, in turn, are actuated by ASCO Solenoid Valves which control the flow of hydraulic fluid to the Askania fuel and air reversal valves.

Manufacturers and operators of apparatus which requires automatic control of the flow of gas or liquid are invited to discuss their problems with our engineers. We have been serving industry in this way for many years and numerous leading companies have standardized on ASCO Solenoid Valves for the necessary precision-control.

. . . .

We also manufacture a quality line of Automatic Transfer Switches, Remote Control Switches, Contactors and Relays

ASCO Solenoid VALVES

Automatic Switch Co.

49 EAST 11th STREET, NEW YORK 3, N. Y.

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WALDES TRUARC RETAINING RING

Re 18144
U. S. Patent

Waldes Truarc presents a significant advance in retaining rings.

It spreads or contracts without distortion; always retaining its perfectly fitting circular contour.

For thrust-load fixing, shaft and housing applications, Waldes Truarc provides distinct advantages over nuts and bolts or wedges and washers. It reduces dimension and weight, saves material, cuts manufacturing time . . . simplifies assembly and dis-assembly.

On request, we will gladly furnish samples and full data for your tests.

WALDES KOH-I-NOOR-INC • LONG ISLAND CITY, N.Y.

Sole Manufacturers in U.S.A.

Canadian Representatives: Prenco Progress and Engineering Corp., Ltd., 72-74 Stafford St., Toronto

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FOR INDIVIDUALIZED EQUIPMENT PARTS

For more than half a century, the vast KOVEN organization has earned and maintained a reputation for designing and manufacturing individualized equipment parts made to meet exact specifications. That is the reason why busy executives like these six production managers have turned to KOVEN. They have found KOVEN can make a part or parts of their finished product more economically and more efficiently than can be made within their own plant.

KOVEN's trained staff are ready to collaborate with you in designing and building the equipment you need for your wartime production or post-war plans. Call or write for a consultation today. You will not be obligated in any way.

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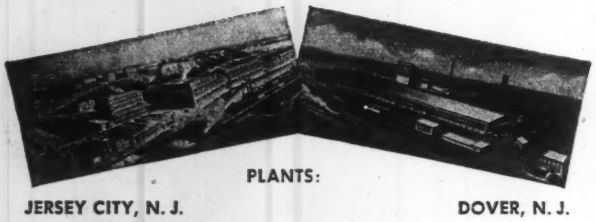
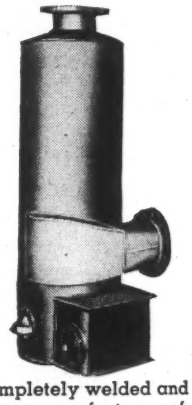
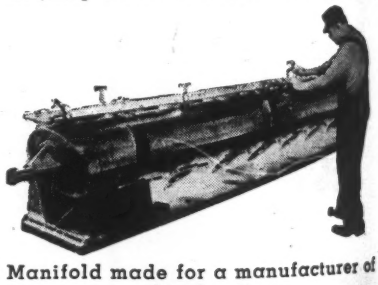
154 OGDEN AVENUE • JERSEY CITY 7, N. J.



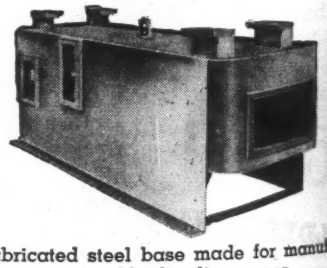
PLANTS:
JERSEY CITY, N. J. DOVER, N. J.



Separator completely welded and made of herculoy for a manufacturer of presses.



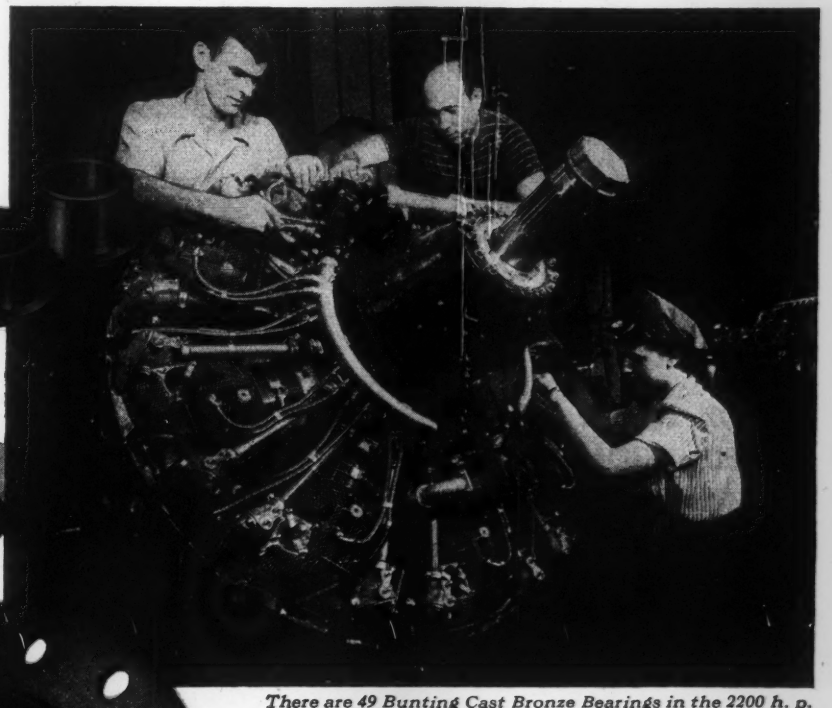
Manifold made for a manufacturer of diesel engines.



Fabricated steel base made for manufacturer of hydraulic presses.

Powered by the Wright Cyclone 18 Engine, the Boeing B-29 Superfortress carries the greatest load—faster—farther—higher than any other airplane in existence.

NEW STANDARDS *for* BEARINGS



There are 49 Bunting Cast Bronze Bearings in the 2200 h. p. Wright Aeronautical Corporation Cyclone 18 Engine.

● With new equipment, exacting new operations and further metallurgical refinements Bunting is producing, in volume, bearings with physical characteristics, accuracy and finish heretofore attainable only in the laboratory.

Such bearings and production processes, developed to serve aircraft and aircraft engine manufacturers, are equally available to all manufacturers requiring aircraft precision and finish. The Bunting Brass & Bronze Company, Toledo 9, Ohio. Warehouses in principal cities.

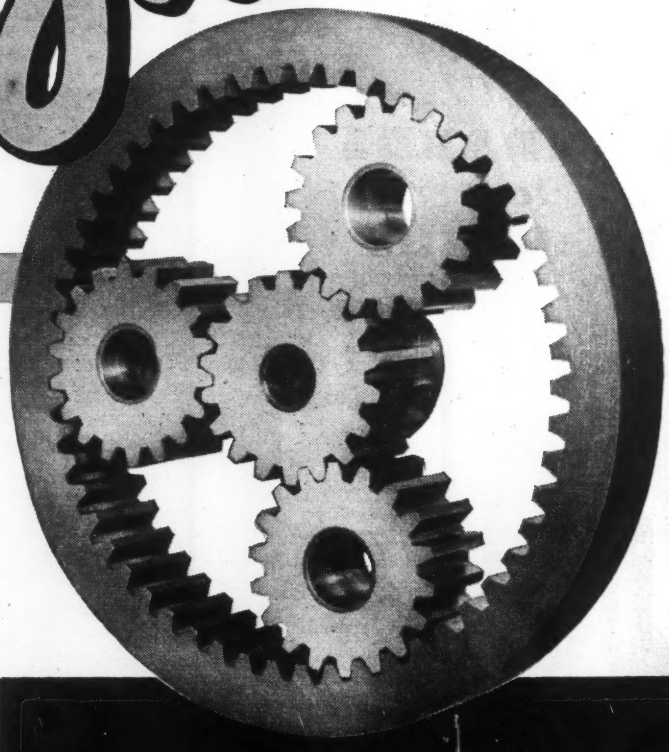
8

Bunting

BRONZE BUSHINGS ☆ BEARINGS ☆ PRECISION BRONZE BARS

D. O. James

ESTABLISHED 1888



FOR LARGE SPEED REDUCTIONS AND GREATEST EFFICIENCY

SINCE 1903 . . . D. O. James planetary Gear Reducers have been used on many industrial applications where large reductions were needed. The superior gear arrangement of this type of reducer obtains highest ratios and greatest efficiency. They are most compact and occupy very little floor space. The equal balance and similar revolving direction of the rolling contact of the gear teeth produces the maximum reduction with the minimum number of gears.

TODAY . . . Modern manufacturing methods and facilities, under the supervision of an experienced operating personnel, assure the utmost efficiency and durability to D. O. James Gears and Gear Speed Reducers.

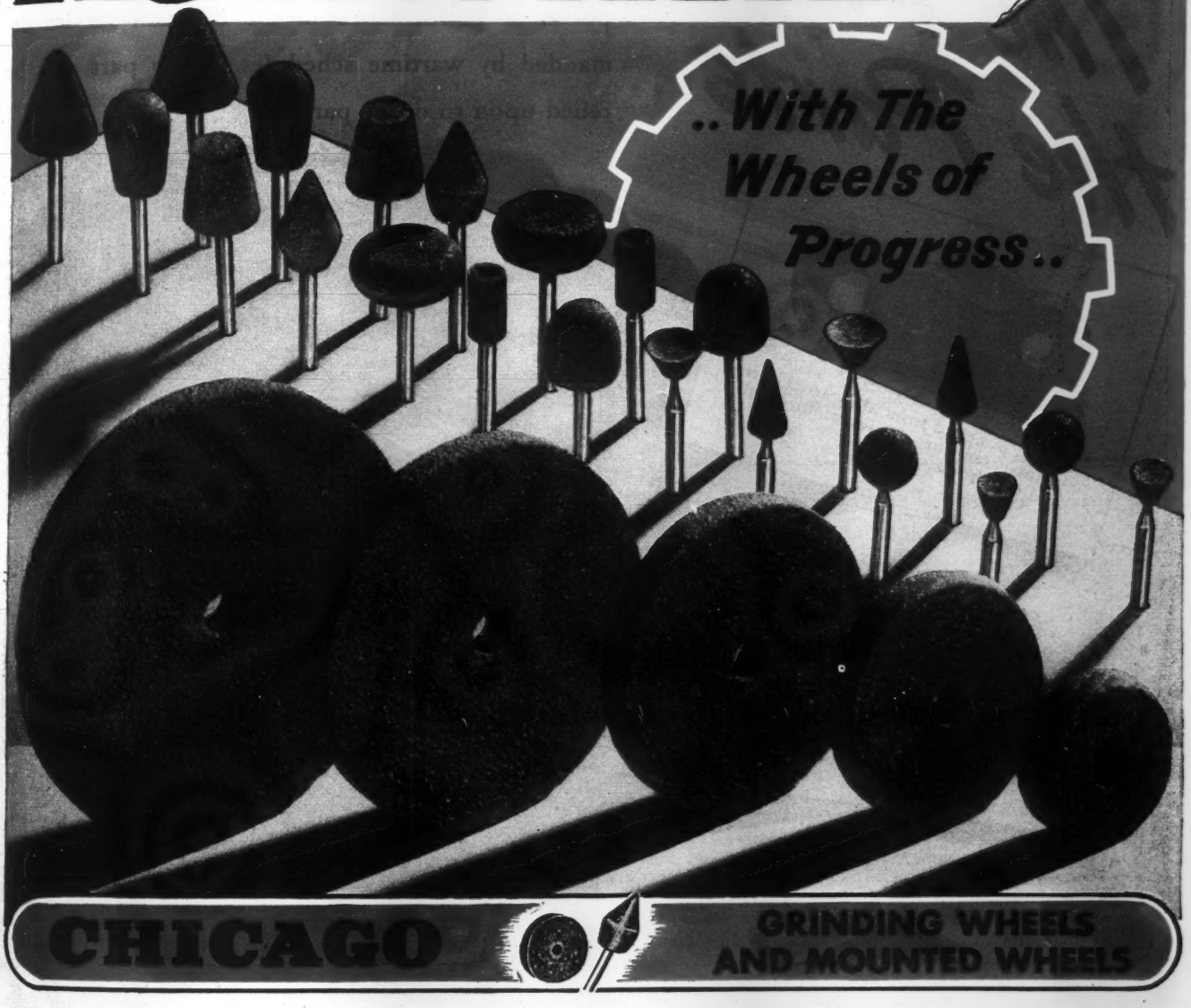
D. O. JAMES MANUFACTURING COMPANY
1140 W. Monroe St., Chicago 7, Ill.

PLANETARY GEAR SPEED REDUCER

Horizontal Drive, 35 Sizes, Ratio 10 to 1200:1, 3/4 to 75 Horsepower

56 YEARS MAKERS OF EVERY TYPE OF GEAR AND GEAR REDUCER

FORWARD



CHICAGO GRINDING WHEELS AND MOUNTED WHEELS

● Geared to the precision demands of war, Chicago Wheels have been a potent force in smashing bottlenecks—cutting down rejects—speeding production to an all-time high.

Constantly tested, constantly improved—Chicago Wheels produce finishes so perfect they pass exacting surface analyzer tests, so accurate they can be measured in micro inches.

Production of civilian goods will demand the same precision finishing methods.

Keep pace with Chicagos, the Wheels of Progress!

CHICAGO GRINDING WHEELS

Anything up to 3" in diameter in various grains and bonds, including FV, the sensational new bond with a pedigree.

CHICAGO MOUNTED WHEELS

Shapes and abrasive formulas to take care of every job of internal or external finishing.

TRY ONE FREE!

So you'll know what they can do, we will send a test wheel. Tell us material you'd like to finish and size wheel required.

MD-12

Send Catalog. Interested in ☐ Grinding Wheels ☐ Mounted Wheels. ☐ Send Test Wheel. Size.....

Name.....

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CHICAGO WHEEL & MFG. CO.

Half a Century of Specialization has Established our Reputation as the Small Wheel People of the Abrasive Industry

1101 W. Monroe St., Dept. MD, Chicago 7, Ill.

The Proof is in the Parts

Whitney Roller Chains are built to give positive, powerful performance in the constant service demanded by wartime schedules. Every part may be relied upon to do its part.

THE WHITNEY CHAIN & MFG. CO.
HARTFORD, CONNECTICUT

Don't lay that pencil down

. . . till you show where the Short Cut Fastening Method can be used!

Choosing the fastening device for use in the assembly of your post-war product is a very important decision. It should be settled now, while the product is still in the design stage. Too many products are tooled up and ready to go into production before somebody starts to really question fastening methods. This frequently leads to needless expense, troublesome delays, and costly changes.

You will want to use P-K Self-tapping Screws wherever possible, because this *short cut fastening method* can save you from 30% to 50% in asembly time and labor! It is the *simplest* way to make most asemblies. You eliminate tapping for machine screws, and tap expense – fumbling with bolts and nuts – costly inserts in plastics – riveting in hard-to-reach places.

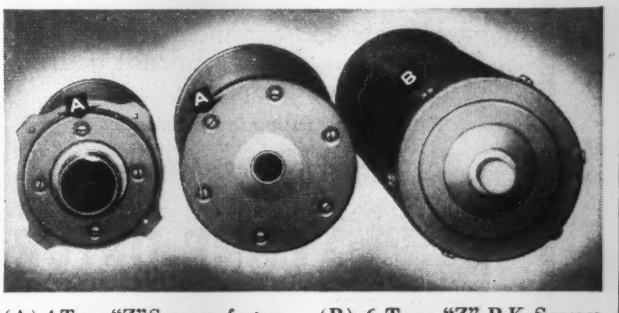
Whether you are working with light or heavy steel, cast iron, aluminum, brass, plastics – you'll find you can use P-K Screws to advantage in 7 out of 10 cases.

A P-K Asembly Engineer will help you plan ahead for savings, and you'll find his advice unbiased. He'll recommend only the best Self-tapping Screw for the job, because Parker-Kalon makes *all* types. Write and tell us when you would like him to call, or send details of your fastening jobs for recomendations.

HELPFUL GUIDE FREE!

The P-K "User's Guide" is crammed full of information on where and how to use P-K Self-tapping Screws, arranged so you can find the facts you need quickly. Write for it. Parker-Kalon Corp., 208 Varick St., New York 14.

HERE'S HOW PUROLATOR PRODUCTS, INC. PLANNED AHEAD FOR ASSEMBLY SAVINGS



(A) 4 Type "Z" Screws fasten sheet metal cap to steel (or aluminum) frame.

(B) 6 Type "Z" P-K Screws fasten the cast iron cap to steel tubing wall.

A Purolator executive says, "We designed most of our filters with P-K Screws in mind . . . to eliminate tapping.

"At least 4 P-K Screws are used in each Purolator unit. If we had to tap holes (800,000 per year) for machine screws, it would require ten times our present labor force, or lower production by the same ratio."

Purolator Products, Inc., make a wide variety of filters for gasoline, oil, air, etc., which are standard equipment on many vehicles, vessels, and airplanes.

PARKER-KALON
Quality-Controlled
SELF-TAPPING SCREWS

SELF-TAPPING SCREWS FOR EVERY METAL AND PLASTIC ASSEMBLY

To Aim Tin Fish more accurately

They used to fire torpedoes one at a time. This war changed that. They now fire tin-fish in squads of two, three, four and even five, blanketing enemy vessels. To train those multiple torpedo tubes, gears have to operate with the smoothness of watch mechanisms yet be able to swing the heavy loaded torpedo turrets rapidly into line. There must be no measurable backlash to spoil the aim. We are proud that many of these training mechanisms are powered with 60 to 80 P. D. Cone-Drive gears and of the job they did in helping our Navy obtain mastery of the seas—East and West. That kind of service should enable Cone-Drive gearing to do a real job tomorrow in improving the design of many peace-time products such as heavy mining machinery, boom hoists, mine hoists, and large indexing drives.

What is more, Cone-Drive gearing saves space and weight. Cone-Drives weigh only 1/3 as much, require only 2/3 the room of conventional gearing of the same load capacity.

Ask for the following manuals:
CW-41B (for Executives)
CW-41A (for Design Engineers)

CONE-DRIVE DIVISION

MICHIGAN TOOL COMPANY
7171 E. McNichols Rd., Detroit 12, U.S.A.

OFFICIAL U. S. NAVY PHOTOGRAPH

SALES REPRESENTATIVES

from Coast to Coast

Birmingham, Alabama
Harry G. Mouat
544 Martin Bldg.

Boston, Massachusetts
Bellamy-Robie, Inc.
45 Main Street
Cambridge, Mass.

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E. J. Ehret, J. D. Kinney
327 So. LaSalle St.

Cincinnati, Ohio
Charles A. Colgate
P. O. Box 803.

Cleveland, Ohio
Dingle-Clark Co.
Engineers Bldg.

Detroit, Michigan
Palmer Shile Company
7100 West Jefferson Ave.

Great Bend, Kansas
Scheufler Supply Co. Inc.

Hartford 7, Conn.
Roger C. Jones,
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Houston, Texas
Industrial Equipment Co.
6823 Navigation Blvd.

Los Angeles, California
J. S. Earhart
1709 W. Eighth Street

New Orleans, Louisiana
Factory Sales and
Engineering, Inc.
816 Howard Avenue

Philadelphia, Pennsylvania
Dingle-Clark Co.
1600 Arch St.

Pittsburgh, Pennsylvania
Edward B. Gray
1011 Keystone Bldg.

Portland, Oregon
Western Gear Works
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San Francisco, California
Pacific Gear & Tool Works
1035 Folsom Street

Seattle, Washington
Western Gear Works
417 Ninth Ave. South

St. Louis, Missouri
Transmission Supply Co.
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St. Paul, Minnesota
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Equipment Co.
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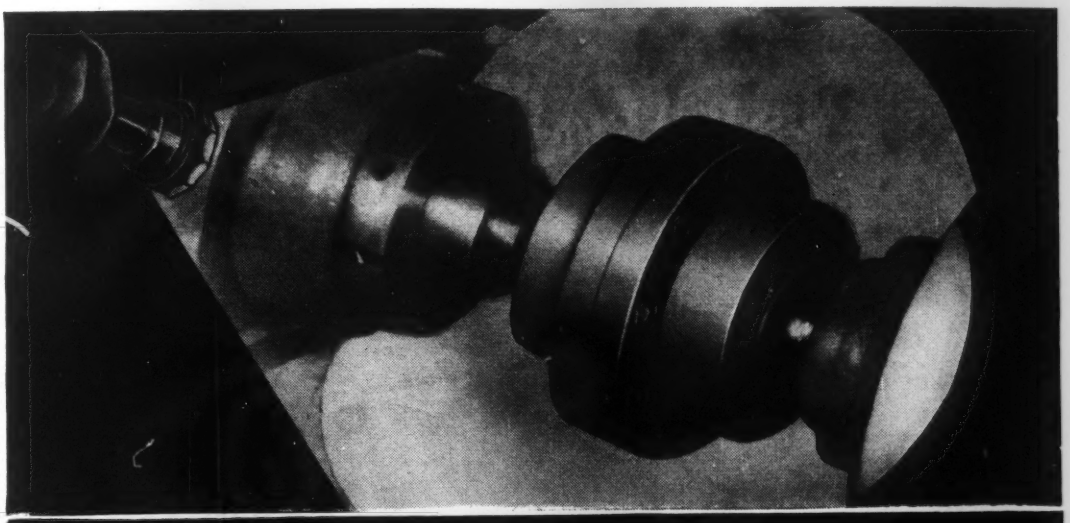


The Perfect Cure For Jitterbug Shafts

It does make a difference which coupling is selected to correct your shaft misalignment troubles. Take the case of a motor generator shaft that becomes misaligned and develops the jitters. An ordinary flexible coupling in trying to take up the misalignment can fatigue and strain shaft and bearings. That means costly repairs—more time and production lost!

* * *

The Waldron Gear Type Coupling is designed and constructed to avoid all 4 major causes of such stoppages. It has no flexible hub connections to fatigue; it affords freedom of movement between cover sleeve and hub to eliminate stress on shaft and bearings. Its forged steel parts and automatic pressure lubrication of all moving parts prevents excessive wear and the need for frequent repair and replacement. An ingenious and positive seal keeps a constant supply of CLEAN oil inside the coupling guarded against contamination from outside dust and dirt.

Compare the design and operating features of this Waldron coupling with those of any other make. Then you will understand why it is being specified in so many plants where trouble-free operation is a major consideration.

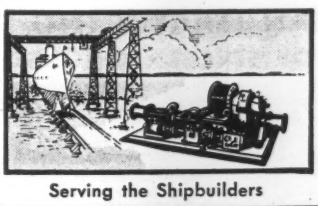
Get in touch with the Waldron Representative nearest you. Our Catalog No. 56 gives full details, rating tables, etc. Sent on request.

WALDRON GEAR TYPE **COUPLING**

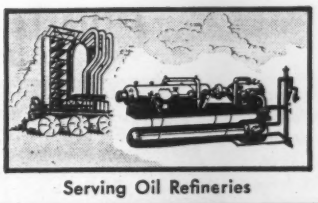
Manufactured by

JOHN WALDRON CORP. New Brunswick, New Jersey

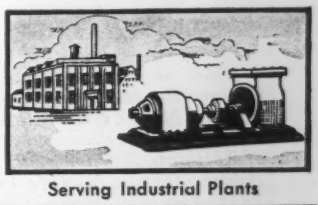
Serving Public Utilities



Serving the Shipbuilders

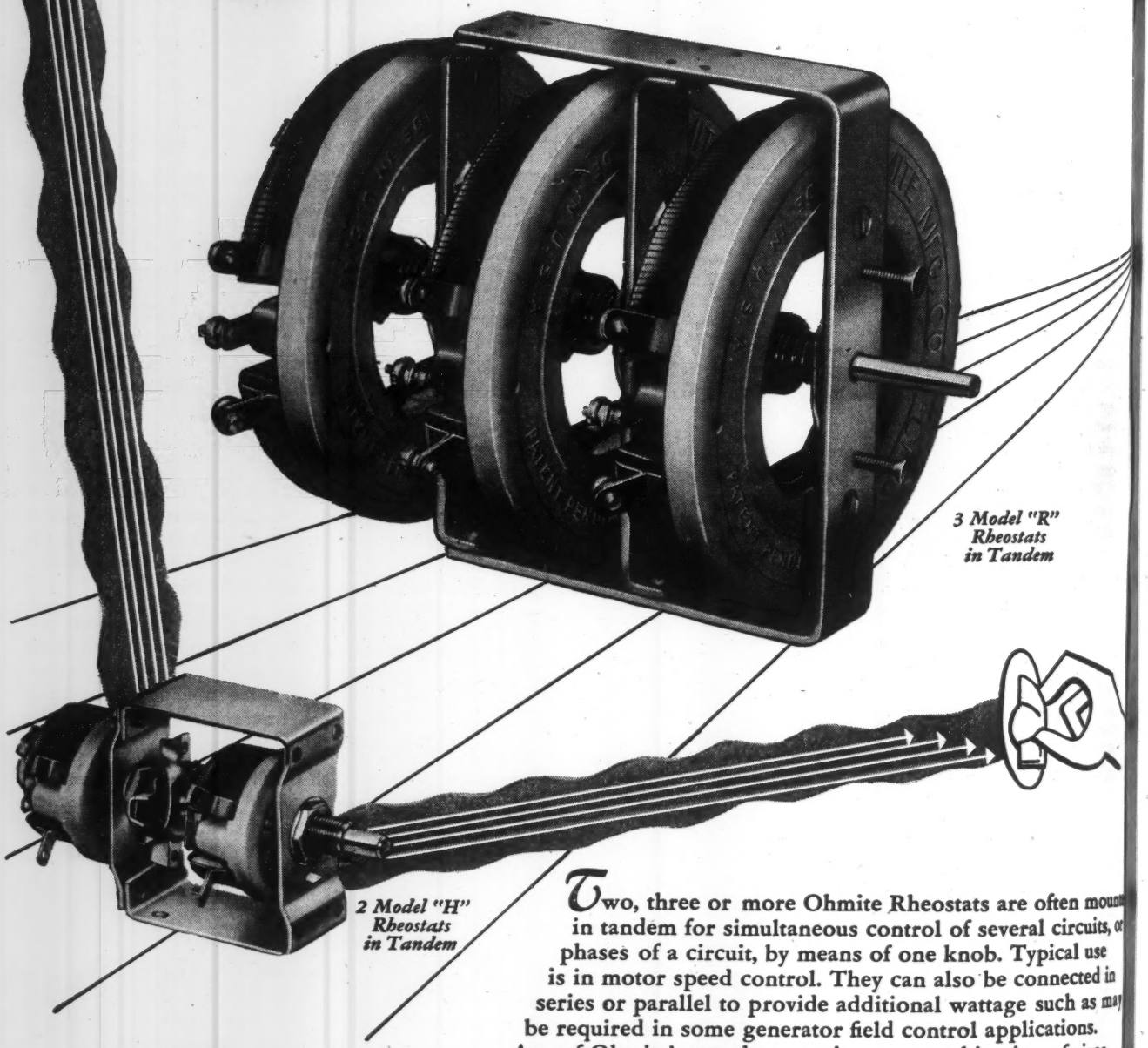


Serving Oil Refineries



Serving Industrial Plants

OHMITE Rheostats in Tandem
For Simultaneous Control of Several Circuits



3 Model "R" Rheostats in Tandem

2 Model "H" Rheostats in Tandem

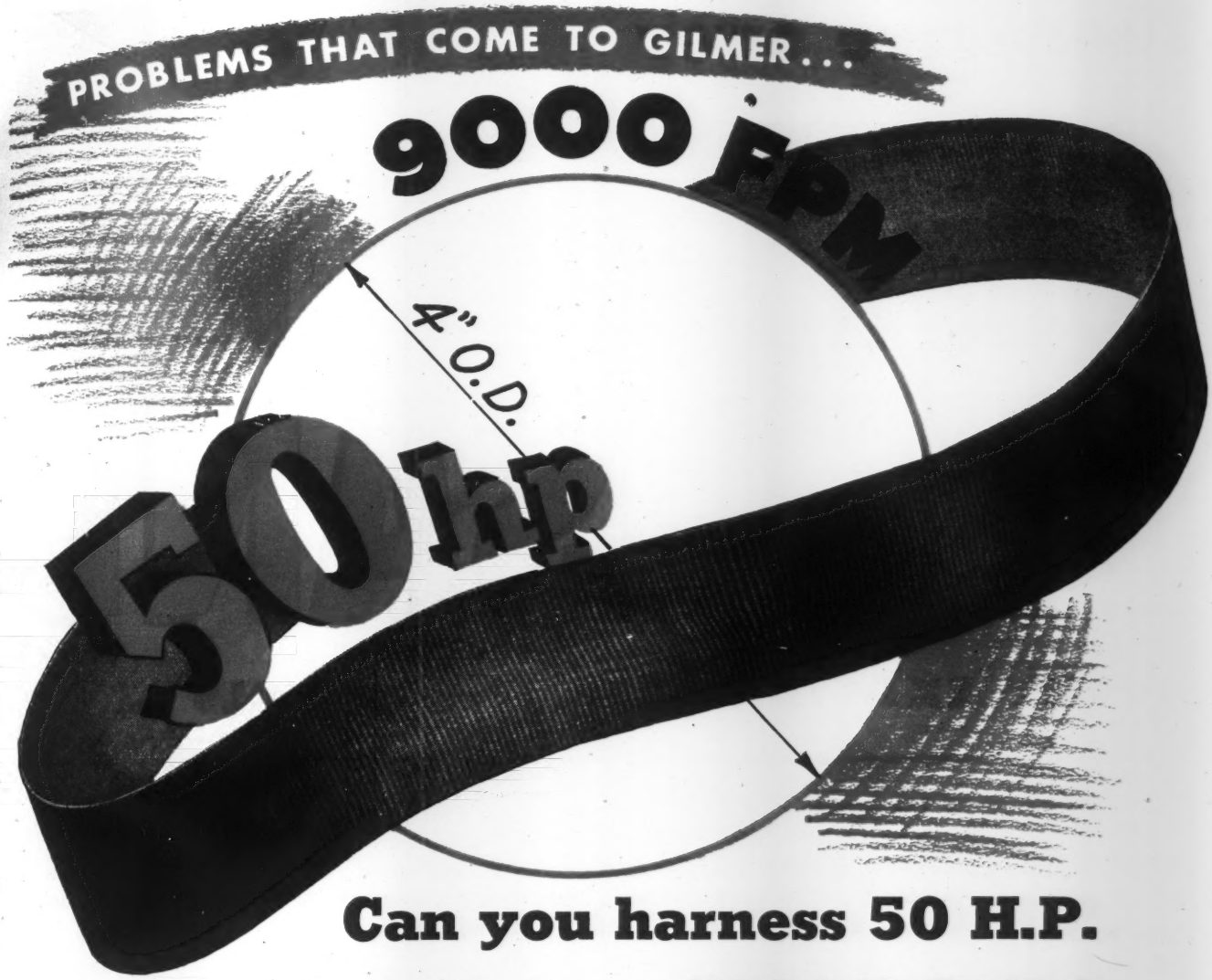
Two, three or more Ohmite Rheostats are often mounted in tandem for simultaneous control of several circuits, or phases of a circuit, by means of one knob. Typical use is in motor speed control. They can also be connected in series or parallel to provide additional wattage such as may be required in some generator field control applications. Any of Ohmite's ten rheostat sizes, or combination of sizes, may be utilized... rheostats ranging from 25 watts to 1000 watts and from 1-9/16" to 12" diameter... with uniform or tapered windings. Concentric control assemblies can also be produced.

In Resistance-Control, Ohmite Experience Makes a Difference!

• *Write on company letterhead for Industrial Catalog and Engineering Manual No. 40. Gives helpful information on the selection and application of Rheostats, Resistors, Tap Switches. Address Ohmite Manufacturing Co., 4831 Flournoy Street, Chicago 44.*

OHMITE MANUFACTURING COMPANY
4831 FLOURNOY STREET • CHICAGO 44, ILLINOIS

Be Right with OHMITE
RHEOSTATS • RESISTORS • TAP SWITCHES



Can you harness 50 H.P. with a light belt at 9000 F.P.M.?

An Industrial Designer brought this tough problem to Gilmer. A centrifuge was belt-driven from a 50 H.P. motor, with a 4" O.D. pulley on the driven shaft. Belt speeds reached 9000 F.P.M., and no known belt lasted more than a few hours. Designer and customer were ready to believe that belts were unsuitable for the job.

Then Gilmer's engineers tackled the problem, and installed an 8" Gilmer Hevaloid* Belt, 126" long. Today, Hevaloid Belts are lasting for months on an installation where all other belts failed in hours.

Examples such as this are typical of the service given by Gilmer Belts and Gilmer's Design Engineers. Write for Gilmer's Belt Catalogues . . . and don't hesitate to ask the help of Gilmer engineers on special problems.

L. H. GILMER CO., Tacony, Phila., Pa.

***A WORD ABOUT GILMER'S HEVALOID BELTS:**

Hevaloid Belts are made by a patented process, exclusive with Gilmer in the United States. It is a neoprene impregnated endless cotton belting, in which latex penetrates every fibre of the cotton and stays there for the life of the belt. Lightweight Hevaloid Belts are smooth and vibrationless at high speeds, resist heat, oil, stretch and slippage... yet have shock-absorbing qualities for low-speed operation. This is an exclusive Gilmer Product.

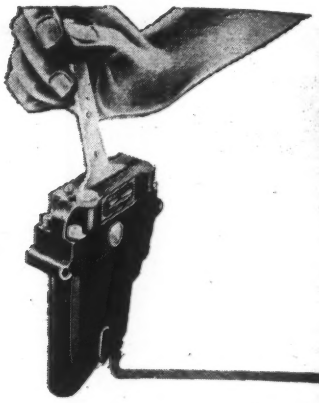
Gilmer BELTS

The Oldest Firm of Rubber Fabric Belt Specialists

V-Belts (F.H.P. & Multiple); Flat Belts; Round Endless Belts; High Speed Belts; Fabric Belts; Planer Belts; Special Endless Belts

There are over

SIXTY THOUSAND



SPERRY EXACTOR REMOTE CONTROLS in use!

Positive control, through a single tube

The Sperry EXACTOR Hydraulic Remote Control is a simple, unique, single-tube system designed to control mechanisms over distances up to 200 feet. The more than 60,000 EXACTORS in operation today, solving the remote control requirements of design engineers in many fields, are proof of the thorough engineering and trouble-free design incorporated in this system.

It is accurate to a fraction of a degree and entirely self-contained, reproducing applied motion without the aid of an auxiliary source of power. It presents no installation problem, because both the Transmitter and Receiver are compact and light in weight, and the tube which connects them can be *bent around* obstacles easily. Vibration does not interfere with its positive, reliable action and means is provided for periodic temperature compensation.

If you have a remote control problem — in the railroad, marine, automotive, aviation, or any of the industrial fields — you will want our completely descriptive booklet. Send for it today.

The Sperry EXACTOR HYDRAULIC REMOTE CONTROL is rated at 400 inch-pounds in one direction, through 55° of motion, and 100 inch-pounds on the return.

FILL OUT AND MAIL COUPON BELOW • NO OBLIGATION

SPERRY PRODUCTS, INC.
HOBOKEN • NEW JERSEY

Gentlemen: Please send me, at no cost, a copy of your Bulletin 78-D containing complete details on your EXACTOR HYDRAULIC REMOTE CONTROL.

NAME..... TITLE.....

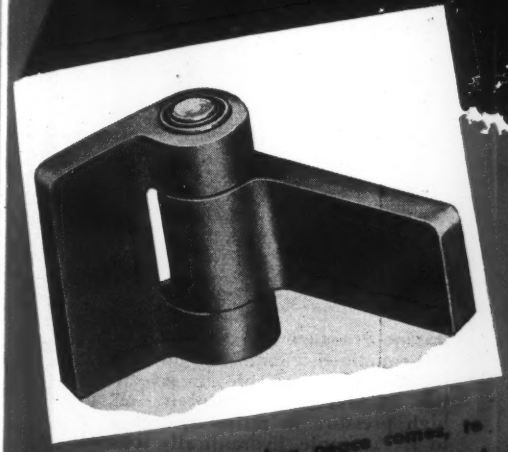
COMPANY.....

ADDRESS.....

CITY..... STATE.....

M.D. EHC-1244

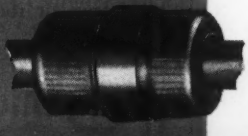
BULLETS MAY BATTER, DENT AND BEND *Escape Doors* BUT NOT JAM 'EM



The switchover, when peace comes, to industrial uses will be many and varied and when released from our war efforts, we will again work with industry in the production of peacetime products.

BECAUSE OF *Torflex* BEARING HINGES

U. S. tanks are pounding their way to victory in all theaters of war and one of the component parts of this mobile fortress is Harris *Torflex* Bearings. ◆ Battlefields are undoubtedly the greatest of all proving grounds, and it is on these battlefronts that *Torflex* bearings are daily demonstrating the remarkable ease in which they in conjunction with shock absorbers cushion shock, stop vibration and reduce noises. ◆ *Torflex* bearings have also helped immeasurably in increasing the firing accuracy on tanks by absorbing vibrations and steadying the tank considerably when in action. This is just one of the many vital war jobs *Torflex* bearings are handling.



HARRIS PRODUCTS COMPANY

Specialized Rubber Engineers and Sole Manufacturers of
Duflex VIBRATION INSULATORS (MOUNTS)
Torflex BEARINGS
Torflex COUPLINGS
HARRIS COMPRESSED RUBBER BEARINGS

HARRIS PRODUCTS COMPANY
CLEVELAND 4, OHIO, U. S. A.

RACINE

Oil Hydraulic

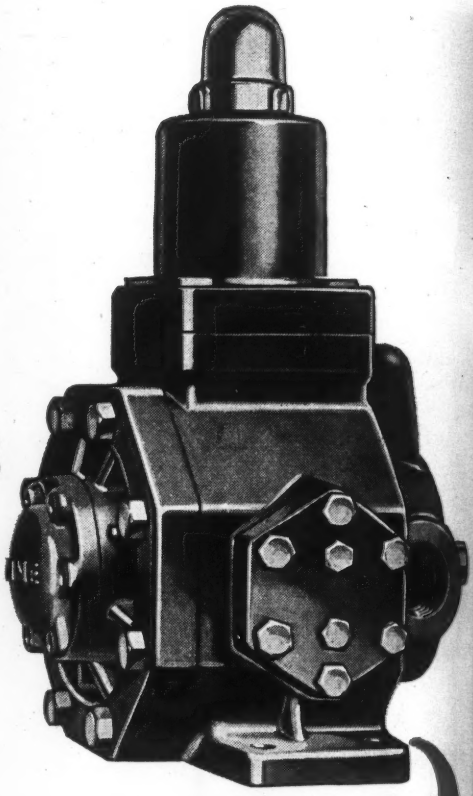
PUMPS and PRESSURE BOOSTERS

The Variable Volume principle incorporated in the design of Racine Pumps reduces horsepower requirements and provides a great flexibility of operation. These pumping units are of the multiple radial vane type, producing a smooth, quiet delivery at all operating pressures.

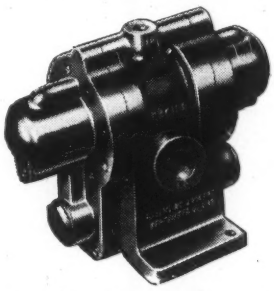
Volume ranges from zero to the full capacity of the pump. Changes are accomplished by regulating the relative position of the pressure chamber ring to the rotor. These changes are available under automatic, manual or hydraulic control. High efficiency is inherent in the simple design of Racine Pumps and is safeguarded by skilled workmanship and the maintenance of exacting tolerances on all parts.

Racine Hydraulic Pumps, Valves, Controls and Pressure Boosters have been used for many years in a wide variety of applications. Manufacturers of machine tools, presses, molding machines, lifts, stokers and a large group of other products, have standardized on Racine equipment.

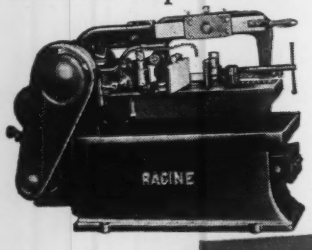
Consult our Engineering Department. Out of their long and varied experience valuable information is available to you without cost or obligation. Write today for a copy of Catalog P-10-C which illustrates the full Racine Line. Address Dept. MD-P.



Racine Variable Volume Pumps — Capacities 12-20-30 G.P.M. Operating Pressures 50 to 1000 lbs. P.S.I. Furnished for either clockwise or counter-clock rotation.



Racine Pressure Booster — Compact, self-contained, requires no special foundation. Available in several ratios. Converts low pressure oil to high pressure in ratios as high as 7 to 1. A simple, hydraulically actuated pumping device adaptable to any circuit. Equally effective with constant and variable volume pumps. 10⅛" high, 8⅛" wide, 18" long.



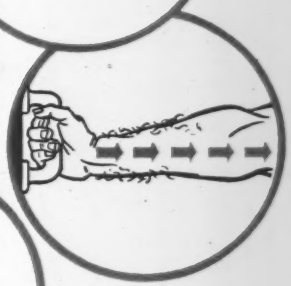
RACINE HYDRAULIC METAL CUTTING MACHINES

For almost 40 years Racine has built constantly improved high speed Metal Cutting Machines. All capacities from 6" x 6" to 20" x 20" are available. See these machines as illustrated in catalog No. 12. Select the model best adapted to your production, maintenance or tool room job.

STANDARD FOR QUALITY AND PRECISION
RACINE
RACINE TOOL and MACHINE CO.

RACINE TOOL and MACHINE COMPANY
Standard for Quality and Precision
RACINE, WISCONSIN, U. S. A.

SPEED PRODUCTION WITH THIS *mechanical manpower*



FOR POWER MOVEMENT IN ANY DIRECTION

To make the most of your manpower—and to obtain greater speed and efficiency in production—*eliminate muscular effort for mechanical movements* by applying T-J Cylinders!

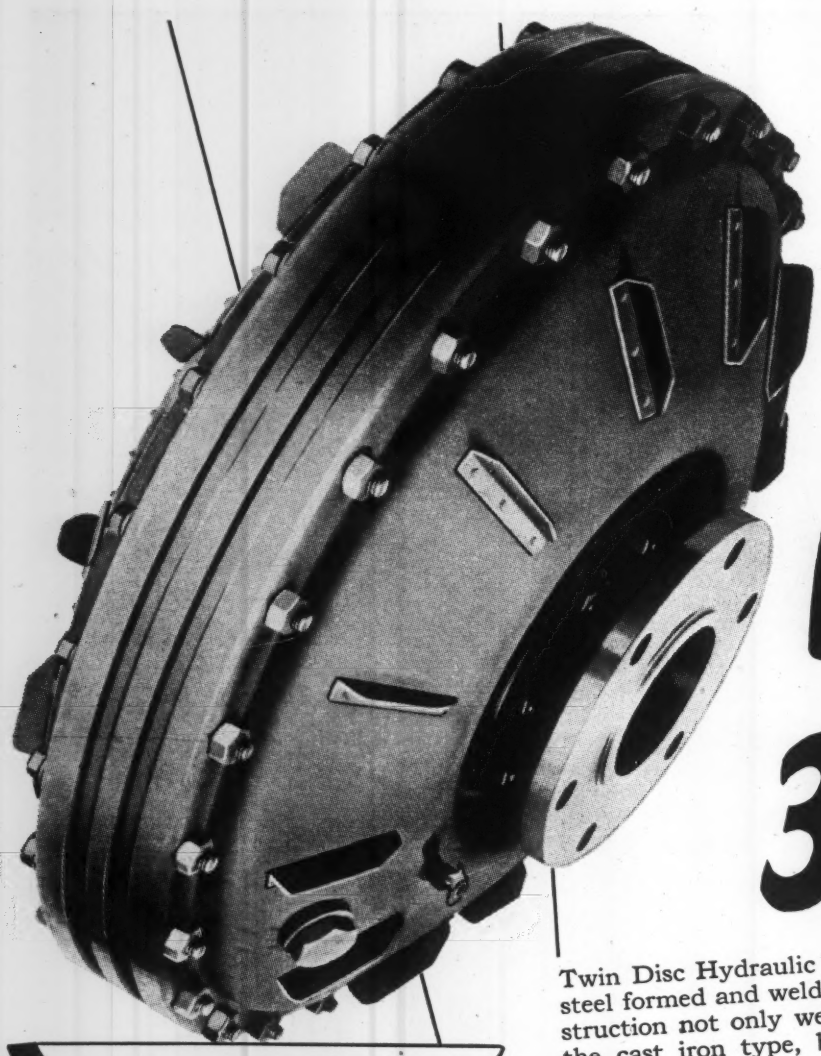
Shop men everywhere today find that operations requiring any form of pressure—to clamp, press, raise or shift—can often be improved and simplified by doing the job with T-J Air or Hydraulic Cylinders! These Cylinders are built *right* to deliver maximum power movement in every stroke... with utmost dependability and long life. All surfaces are strictly inspected for squareness and smoothness. All mounting holes are drilled—not just cored. Available in many sizes and styles... write for latest T-J Cylinder catalogs.

The Tomkins-Johnson Company, Jackson, Michigan.

FOR TOUGH JOBS SPECIFY T-J

TOMKINS-JOHNSON

RIVITORS...AIR AND HYDRAULIC CYLINDERS...CUTTERS...CLINCHORS



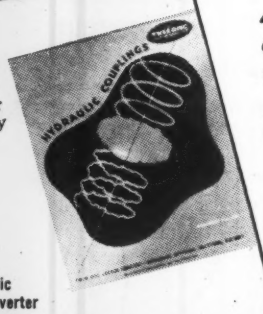
WEIGHS 30% LESS

Twin Disc Hydraulic Couplings are fabricated from sheet steel formed and welded into solid units. This type of construction not only weighs, on the average, 30% less than the cast iron type, but also gives you these added advantages:

1. *A more responsive coupling*—easier to get in motion—easier to stop because there is less inertia—less "flywheel effect."
2. *Minimum axial length*—this means a more compact unit.
3. *Increased capacity* and efficiency because more blades can be used in the same space.
4. *Less skin friction* of the fluid within the unit because of the comparative surface smoothness of sheet steel as against unmachined castings.
5. Can be *operated at higher speeds*, thus increasing the h.p. capacity for a given size.

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin
(Hydraulic Division, Rockford, Illinois).

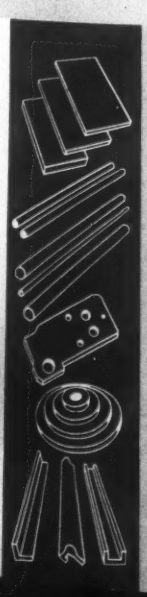
A NEW BULLETIN for engineers, designers and builders of industrial machinery is now ready for distribution. Write for your copy of Bulletin No. 136.



TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES
REG. U.S. PAT. OFF.

SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918

Leeuwenhoek Saw a New World in a Tiny Bead of Glass



SHEETS

RODS

TUBES

FABRICATED PARTS

MOLDED-MACERATED and MOLDED-LAMINATED FORMS and PRODUCTS

HISTORY does not reveal who invented the microscope. But it was a Dutch merchant, Anthony Van Leeuwenhoek who made it practical. Peering through a tiny bead of glass he ground into a lens, he became the first to see the organisms of the microscopic world.

This kind of inquisitiveness still pays. For example, present-day investigators are bringing into view many practical new uses for plastics. You may initiate and benefit from these newer or wider uses. Here's how. You know best what properties—physical, electrical, chemical or mechanical you require of a material. Give us this information to start on and we'll be glad to let you know whether our type of technical plastics can help you in current or future plans. In any case, write today for the complete catalog of Synthane technical plastics.

Synthane Corporation, Oaks, Penna.

SYNTHANE TECHNICAL PLASTICS

SHEETS • RODS • TUBES • FABRICATED PARTS **SYNTHANE** MOLDED-LAMINATED • MOLDED-MACERATED

Plan your present and future products with Synthane Technical Plastics

THERE ARE A THOUSAND USES FOR SYNTHANE LAMINATED PLASTIC TUBING

Tubing is the start in the production of many products

SYNTHANE TUBING is produced in various shapes, diameters, wall-thicknesses, lengths, colors and finishes. The uses of tubing, simply as tubing, however, are obviously limited. It is imagination and machining plus a combination of many desirable properties that make Synthane tubing the useful material it is. Tubes can be easily and quickly machined into coil forms, fuse cases, chemical piping, motor brush holders, bushings, ferrules, ball bearing retainers, pump valves and a legion of other products. Tubing, then, is the first step in the ready and economical production of many parts.

Machining can be done by you or by us. Many prefer us to handle the complete job to relieve them of the responsibility for dies, jigs, tolerances, and other production details.

PROPERTIES—GENERAL (Varies with grades)

PHYSICAL: Hard, Rockwell M-60 to M-100, dense, uniform. Light in weight (specific gravity 1.1 to 1.3), non-hygroscopic, (24 hour water absorption 0.5 to 5.0 per cent). Stable over wide temperature range. Low coefficient of thermal conductivity.

MECHANICAL: High tensile, compressive and crushing strength. High resistance to rupture (under internal pressure). May be easily sawed, turned, punched, riveted, drilled, reamed, milled, threaded, tapped or polished.

ELECTRICAL: High dielectric strength, low dielectric constant, low power factor, low loss factor.

CHEMICAL: Resists common solvents, oils, weak acids. Will not corrode metal inserts, bushings, ferrules, etc.

Kinds of stock, properties

There are three principal kinds of SYNTHANE tubing, classified according to the materials used in their manufacture:

1. The paper base grades—X and XX.
2. The fabric base grades—C, CE, L and LE.
3. The asbestos base grades—A and AA.

The properties and characteristics of SYNTHANE tubing depend mainly upon the base used, the type of resin and the time of cure. By combining the raw materials and varying the method of manufacture, it is possible to alter the physical, mechanical, electrical or chemical properties, strengthening one without wholly sacrificing the others, to secure the exact balance of properties required.

The services of SYNTHANE engineers are at your disposal to aid in selecting or developing tubing to meet your particular needs.

Special shapes

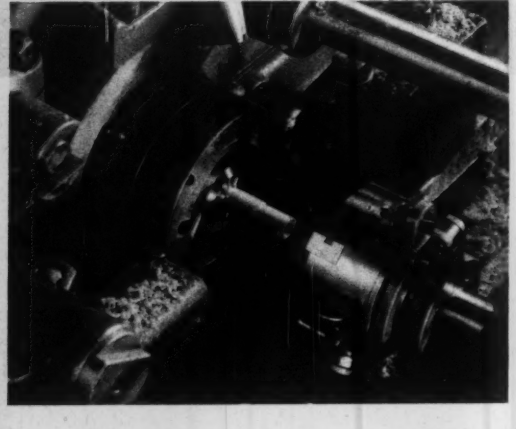
Special tubular sections can be produced in a wide variety of forms by applying the basic principles of tube molding. SYNTHANE sections, being laminated, are considerably stronger than ordinary powder molded shapes.

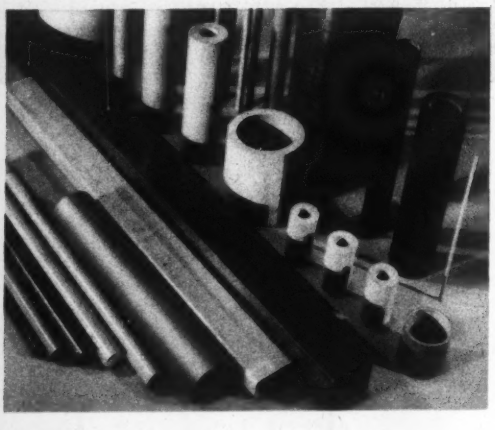
The simplest molded-laminated shapes are square, rectangular or oval. More intricate examples include horns, cones and irregular inside or outside contours.

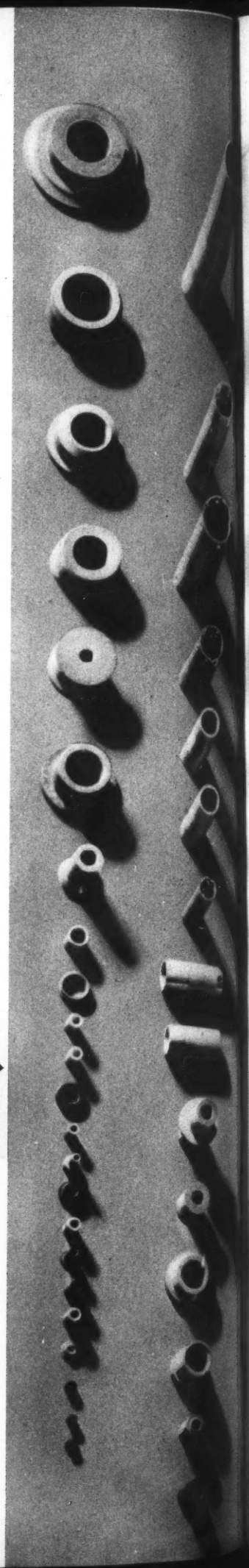
Automatic screw machining can be advantageously used for low cost quantity production of numerous parts from Synthane tubing.

From tubes like these . . .

products like these ➡







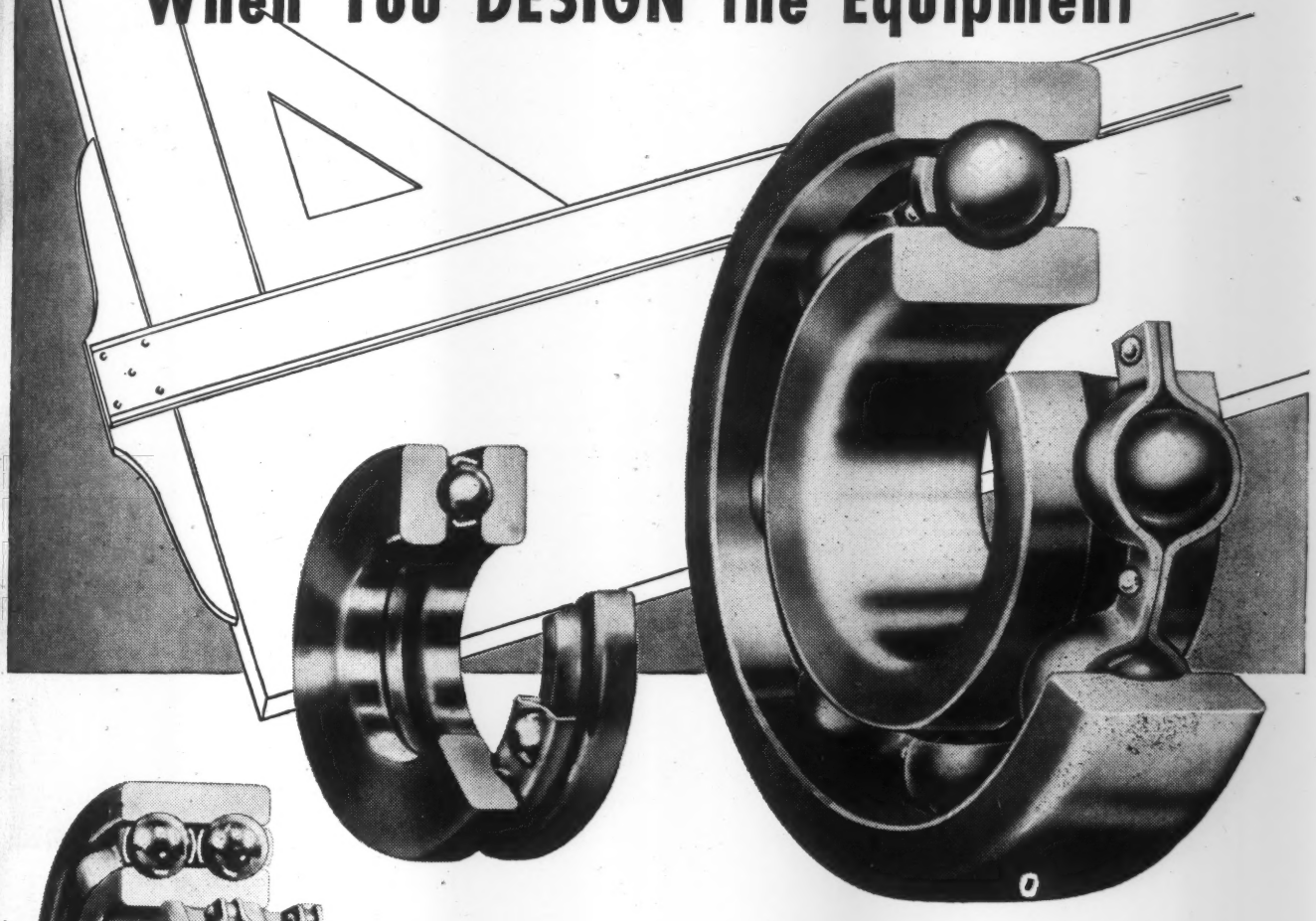
SHEETS • RODS • TUBES • FABRICATED PARTS **SYNTHANE** MOLDED-LAMINATED • MOLDED-MACERATED

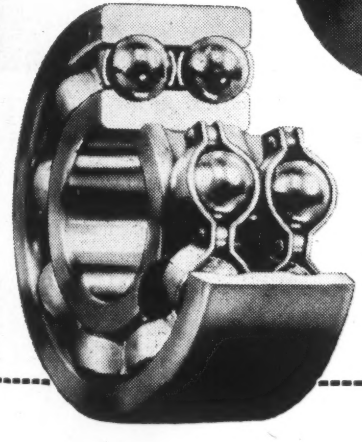
Plan your present and future products with Synthane Technical Plastics

SYNTHANE CORPORATION, OAKS, PENNA.

REPRESENTATIVES IN ALL PRINCIPAL CITIES

Reduce Equipment Maintenance When You DESIGN the Equipment





Treat Bearings Right! They're in the Fight!

1. Store bearings in a dry place and do not unwrap them until ready to use.

2. When mounting bearings, protect the shaft and be sure that the housing covers are tight to prevent entry of dirt.

3. Use only neutral mineral lubricants and do not over-lubricate.

DURING and after reconversion, equipment users will be in a position to demand higher performance levels. The manufacturer who does not burden users with maintenance problems but who *eliminates them through sound planning in his own engineering department* will gain an important competitive advantage.

Consult the BCA catalog for engineering data, load figures and other technical information *at the time your equipment is being planned.* Every BCA Ball Bearing is carefully engineered to reduce friction and wear—two of the most important factors in maintenance. Study the possibilities of these bearings *now.*

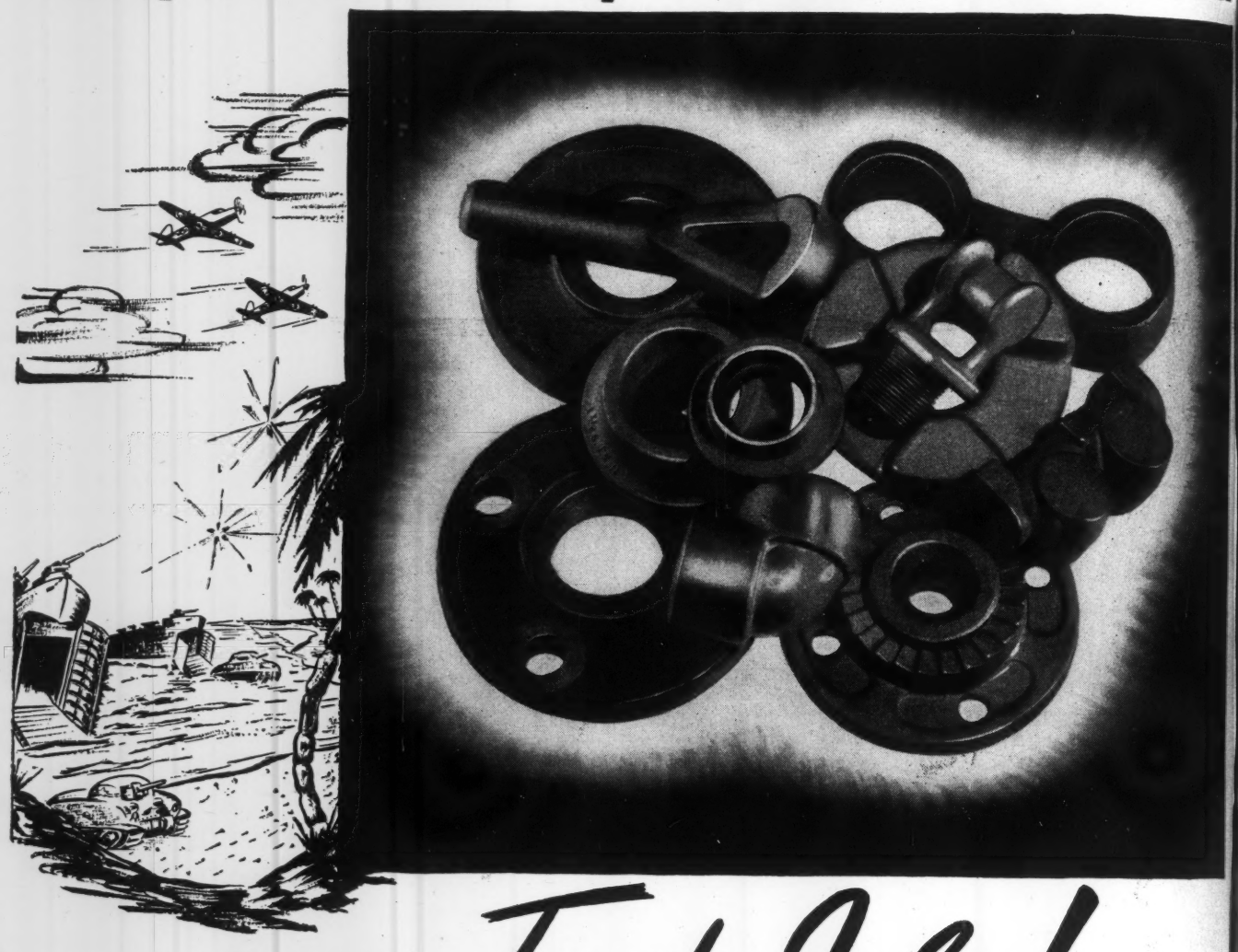
BEARINGS COMPANY OF AMERICA, LANCASTER, PENNA.

BCA

RADIAL • ANGULAR CONTACT • THRUST

BALL BEARINGS

Why FORGINGS by PHOENIX are chosen



for the *Tough Jobs!*

Forgings by Phoenix are chosen for jobs where extra strength and endurance are demanded . . . where weight must be held to a minimum . . . where production efficiency and economy are important factors. Why? Because Forgings by Phoenix provide these six important advantages:

1. STRENGTH. Controlled grain flow and proper distribution of metal provide maximum tensile, torsional, and impact strength.

2. ENDURANCE. High fatigue resistance, toughness, and stamina insure long, trouble-free service.

3. LOW MACHINING COST. Formed in closed dies to close tolerances, there is no excess bulk of metal to be removed.

4. WEIGHT REDUCTION. Extra strength in lighter sectional thicknesses permits reduction in weight without sacrificing heavy-duty ruggedness.

5. SAFETY. Freedom from concealed defects materially reduces danger of failure in action.

6. WELDING ADAPTABILITY. For the fabrication of complicated assemblies from two or more forgings, the widest range of welding adaptability is provided.

Consider these advantages in relation to your product . . . or the one you're planning for the future. Better yet, call in a Phoenix engineer. He'll be glad to discuss your problems with you and give you the benefit of his knowledge and experience. Write today.

Forging Division of

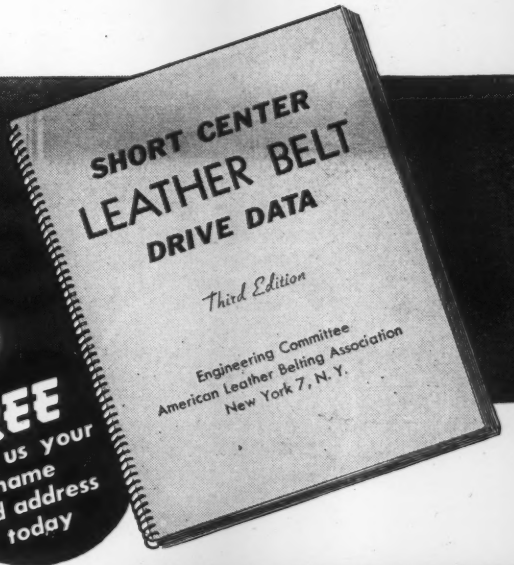
PHOENIX MANUFACTURING COMPANY

CATASAUQUA △ PENNSYLVANIA

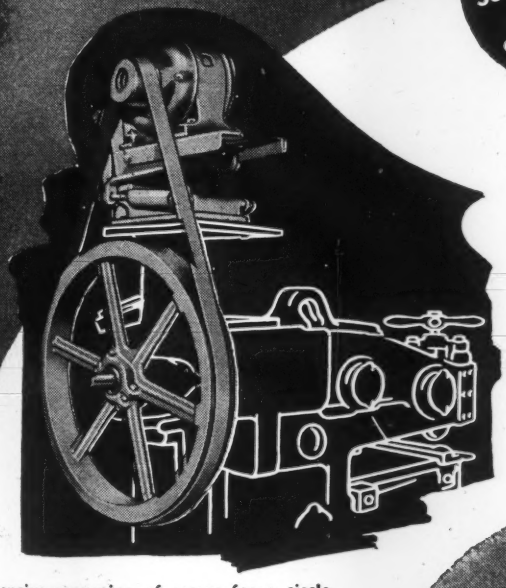
Forgings by **PHOENIX**

THIS NEW DRIVE DATA BOOK

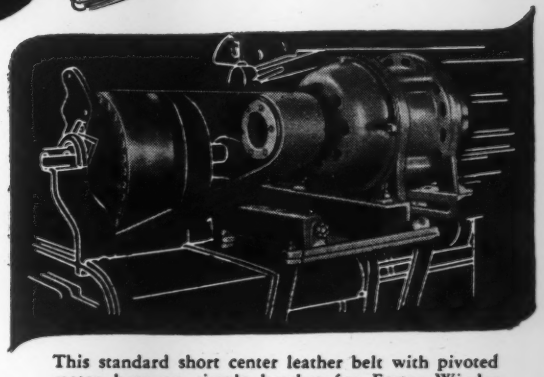
FILLS A LONG-FELT NEED OF MACHINE DESIGNERS



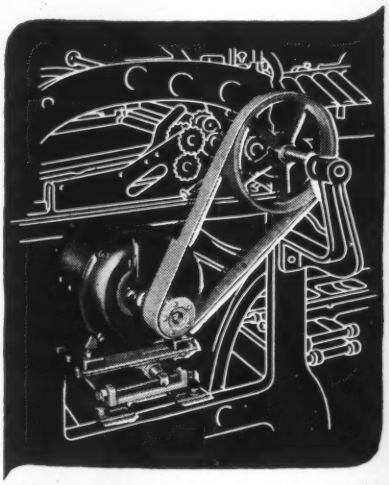
FREE Send us your name and address today



Inexpensive mounting of motor for a circle shear, with a leather belt short center drive, away from floor dust and dirt. Need not be re-mounted if machine is moved.



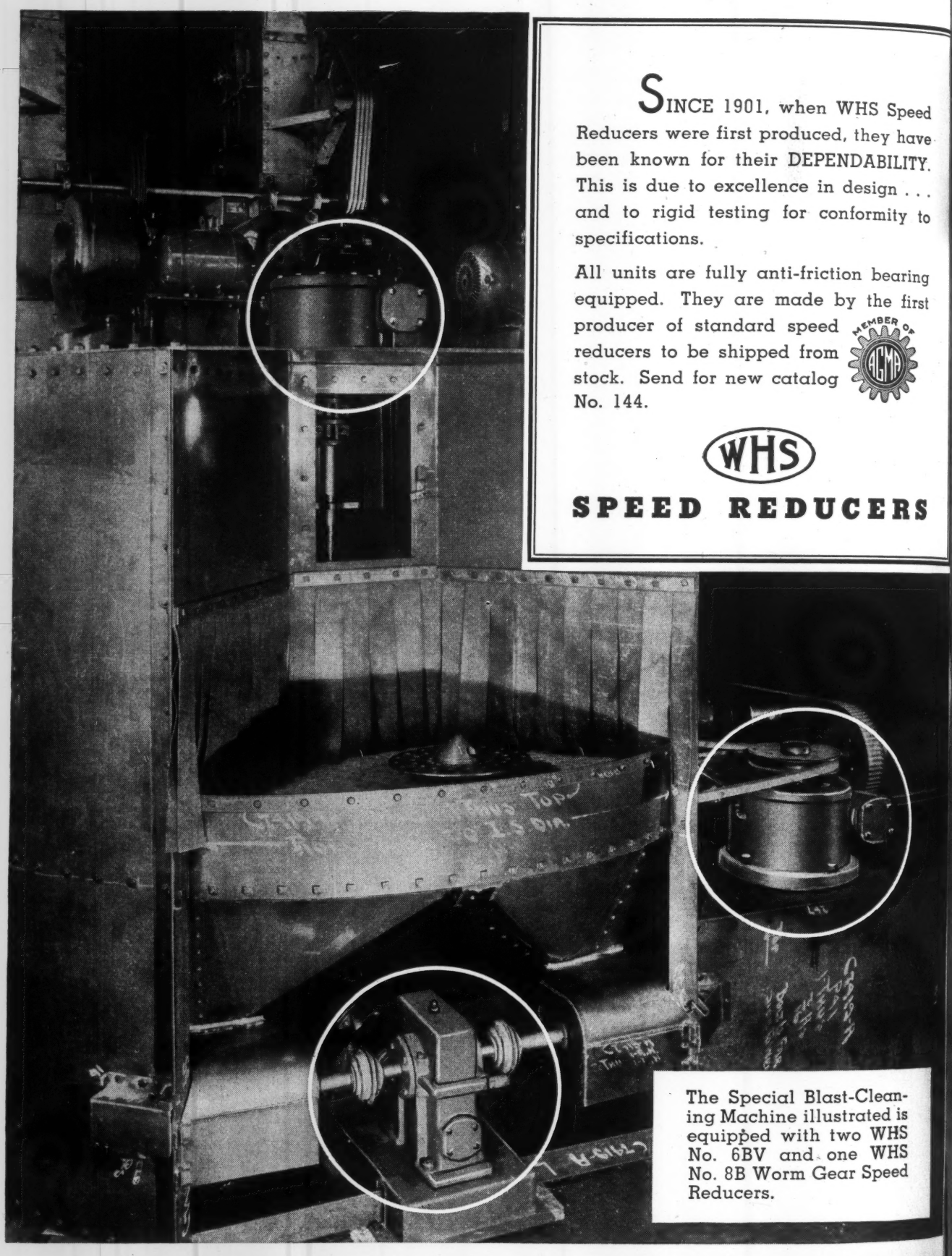
This standard short center leather belt with pivoted motor base on simple bracket for Foster Winder easily becomes an integral part of the machine.



Motor on this printer's folding machine is nicely tucked away so no interference is met by operator. Short center leather belt with pivoted motor base makes dependable, long-lived and economical installation.

Let's talk about using pulleys of ample diameter. . . . On Pages 30 and 31 of the new ALBA Short Center Leather Belt Drive Data Book you will find 3 tables: one giving NEMA recommended pulley diameters, another showing a tabulation of belt speeds for different pulley diameters and RPM, and the third listing the minimum pulley diameters for different belt thicknesses. To quote from notes on page 30: ". . . nearly all unsatisfactory belt drives get that way because *one* of the pulleys — usually the driving pulley is too *small*. . . . Small pulleys do not have as much "leverage" as do larger pulleys. It is desirable, therefore, to use, whenever practical, even larger pulleys than NEMA recommendations." . . . Every Machine Designer should have a copy of the ALBA Drive Data Book on his reference shelf. We shall be glad to send you *your* copy. There is, of course, no charge. Just write to —

AMERICAN LEATHER BELTING ASSOCIATION · 41 Park Row, NEW YORK 7, N. Y.



SINCE 1901, when WHS Speed Reducers were first produced, they have been known for their DEPENDABILITY. This is due to excellence in design . . . and to rigid testing for conformity to specifications.

All units are fully anti-friction bearing equipped. They are made by the first producer of standard speed reducers to be shipped from stock. Send for new catalog No. 144.

MEMBER OF AGMA

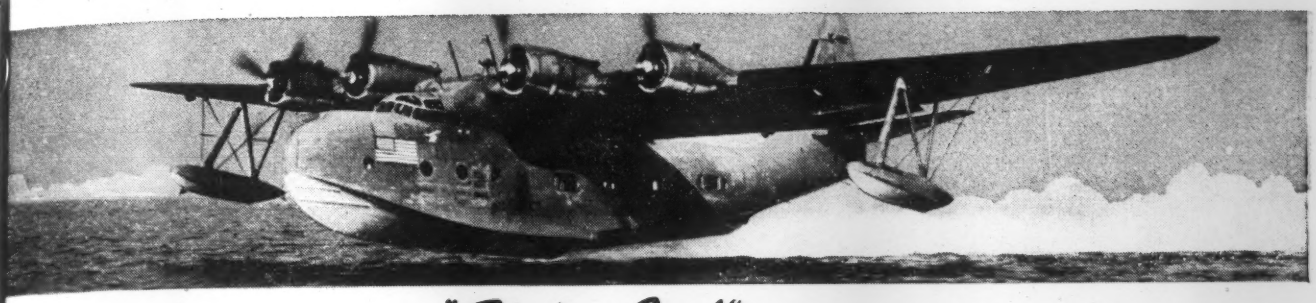
WHS

SPEED REDUCERS

The Special Blast-Cleaning Machine illustrated is equipped with two WHS No. 6BV and one WHS No. 8B Worm Gear Speed Reducers.

WINFIELD H. SMITH, Inc.

36 ELTON STREET . . . SPRINGVILLE . . . ERIE COUNTY . . . NEW YORK



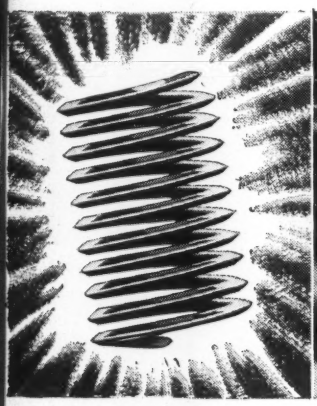
HOW "Heli-Coil" INSERTS REDUCE HOURS TO MINUTES

In the shops of American Export Airlines, Inc., replacement of burned or worn-out spark plug bushings formerly required removal of the cylinder from the engine. This took several hours—often most of a day. Today, "Heli-Coil" Inserts restore the bushings to perfect condition in less than an hour—*without removing the cylinder.* They are easily installed—using only simple hand tools in maintenance operations (see photographs below).

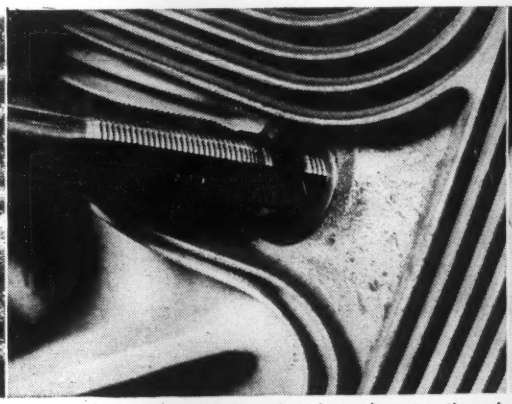
"Heli-Coil" Inserts are also used in original installations as spark plug and stud bushings, providing a tight wear-resistant, leak-proof fitting. They will not corrode in storage or service, and in the case of spark plugs, eliminate freezing and insulation, permitting removal of spark plug with same torque as used for installation. For assembly on a production basis, power tools are available.

"Heli-Coil" Inserts are precision-shaped stainless steel helical coil thread-liners. They engage the retapped thread of the spark plug bushing, or any American National tapped thread providing a permanent, hard, smooth surface. They are about one-fifth the weight of solid bushings and occupy less than half as much cross sectional area, permitting more latitude in design and greater strength. Send for further information.

THE SCREW SYSTEM WITH THE ANTI-FRICTION THREAD LINING



U. S. and Foreign Patents Issued and Pending



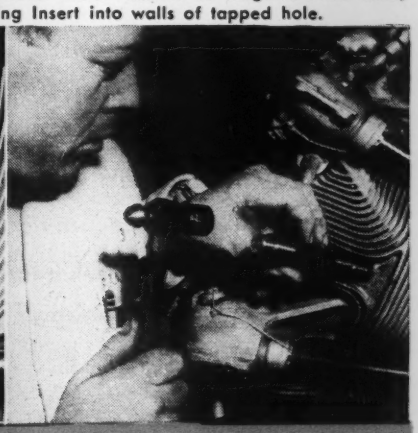
REAMING out old thread and tapping new thread for the "Heli-Coil" Insert, in one operation in shops of American Export Airlines, Inc.

EXPANDING tool ready to be screwed into Insert. Mandrel will then be pushed down into sleeve, forcing Insert into walls of tapped hole.

CLOSE-UP of inserting tool, comprising mandrel and threaded sleeve, with Insert in sleeve.

STAKING sleeve is placed over expanding mandrel until sleeve meets boss. Light blow on top of sleeve knurls chamfered edge around hole, locking Insert into walls of tapped hole.

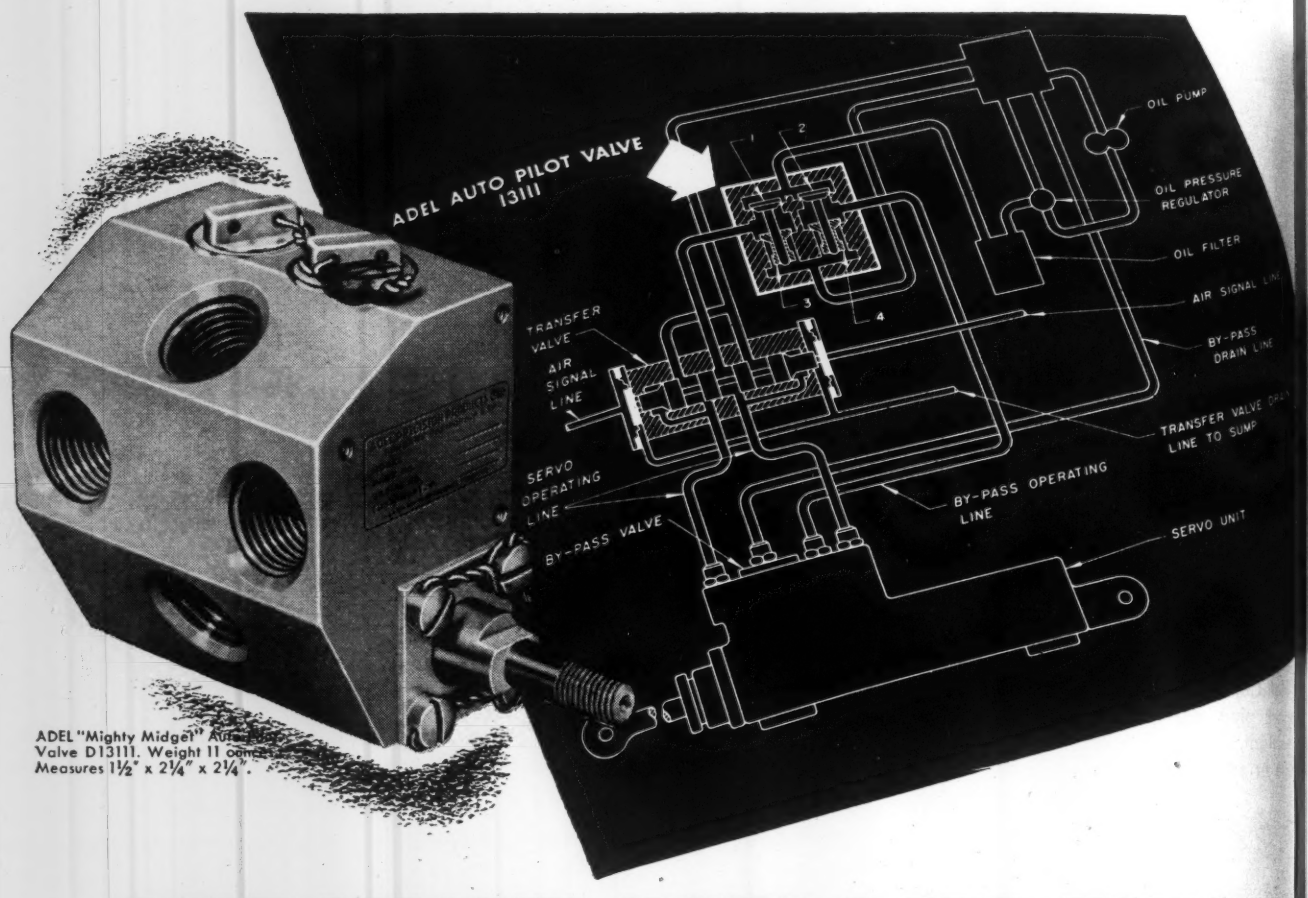
INSERTING tool is placed over the tapped hole and Insert wound through threaded sleeve into hole.



HELI COIL

AIRCRAFT SCREW PRODUCTS COMPANY, INC.

47-23 35th STREET • LONG ISLAND CITY, 1, N.Y.



ADEL "Mighty Midget" Auto Pilot Valve D13111. Weight 11 ounces. Measures 1½" x 2¼" x 2¼".

ONE VALVE REPLACES TWO IN S IV GYRO-PILOT

Approval by Sperry Gyroscope Company of the ADEL "Mighty Midget" No. D 13111 for use in this internationally famous company's S IV Gyro-Pilots is unusual proof of quality and DEPENDABILITY. It replaces two plug valves on installations to date with following advantages: (1) Automatic sequence—no need of manual operation of two plug valves in correct sequence. (2) Reduction of service trouble previously experienced from internal and external leakage. (3) Lower handle loads—15 in. lbs. max. at normal operating pressures.

Accepted for this installation by Bureau of Aeronautics, the unit is identical, except for camshaft, to ADEL "Mighty Midget" AN 6210 and similar to D 10150 which was granted Winterization Yellow Dot Approval. See ADEL for the answer to *your* control problems. Over 500,000 hydraulic, *HYdronic (hydraulic-electric) and *ISOdraulic units now in service—Land, Sea and Air thruout the globe.

For information, see the nearest office or write today.

*Trade Mark

ADEL

ADEL PRECISION PRODUCTS CORP., BURBANK, CALIFORNIA; HUNTINGTON 17, W. VA.

Engineering Service Offices: 1141 Fourth Avenue, Seattle 1, Wash.; 421 Mutual Home Building, Dayton 2, Ohio; 802 Fisher Building, Detroit 2, Mich.; 303 Wareham Building, Hagerstown, Md.; 914 Lexington Building, Baltimore I, Md.; 353 International Building, Rockefeller Center, New York 20, N. Y.

Not So Simple...

...To Engineer A New Product!

This little self-locking nut plate is typical of Solar's challenging spirit which, fifteen years ago, brushed aside tradition to give the world the first really safe method of venting dangerous airplane gases — the Solar stainless steel exhaust manifold.

Two years ago there was a desperate need for self-locking nut plates for military plane production which would sustain high temperatures. Solar met the emergency with SOL-A-NUT... a stainless steel nut plate developed with Solar initiative on different principles of design and construction. SOL-A-NUT is simplicity itself — *now that it is finished.* But back of it are months of hard work and original thinking — of research and design — of material tests — trials in use — re-design and further tests.

It is not a simple matter to engineer new products, particularly those made of stainless steel and used where high temperatures prevail, or hot gases, acids and corrosion are encountered. Design engineers are invited to consult Solar in their problems. Address "Management".

ARMY (E) NAVY ARMY (E) NAVY

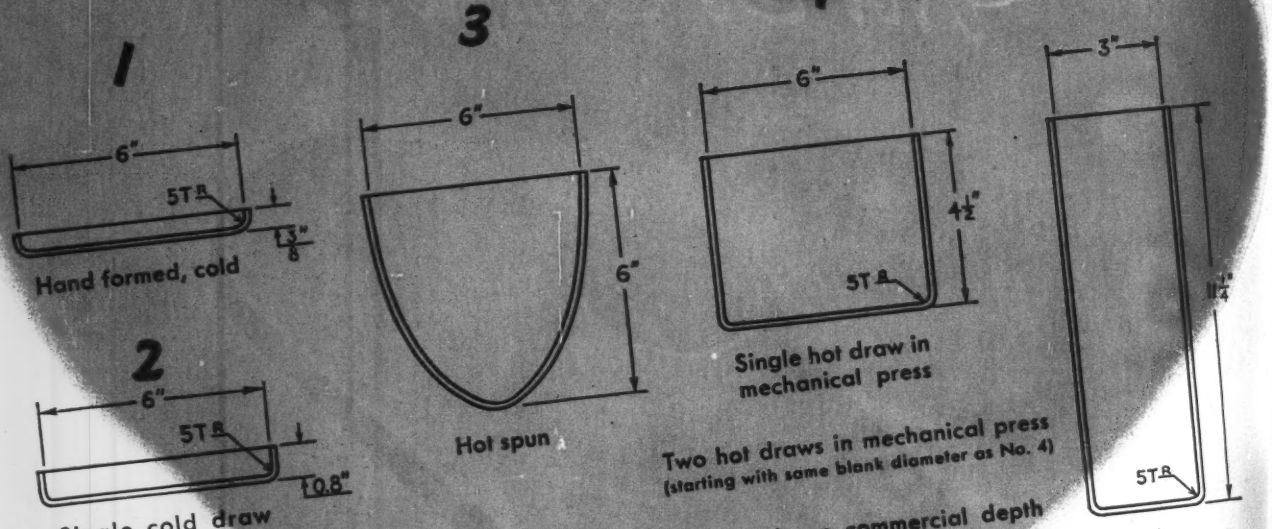
SOLAR

STAINLESS STEEL PRODUCTS

SOLAR

SOLAR AIRCRAFT COMPANY SAN DIEGO 12, CALIF. DES MOINES 5, IA.

Some notes on the Formability of Magnesium sheet



The sketches illustrate schematically the maximum commercial depth of draw in working AM3S-0 and AM-C52S-0 sheet. Proportions are based on round cups formed from 0.064-inch sheet. T=sheet thickness.

"How deep will it draw?". . ."Can it be spun?". . ."Must the metal be heated to produce this shape?" Such questions, and many more, are answered in American Magnesium's book, "Designing with Magnesium".

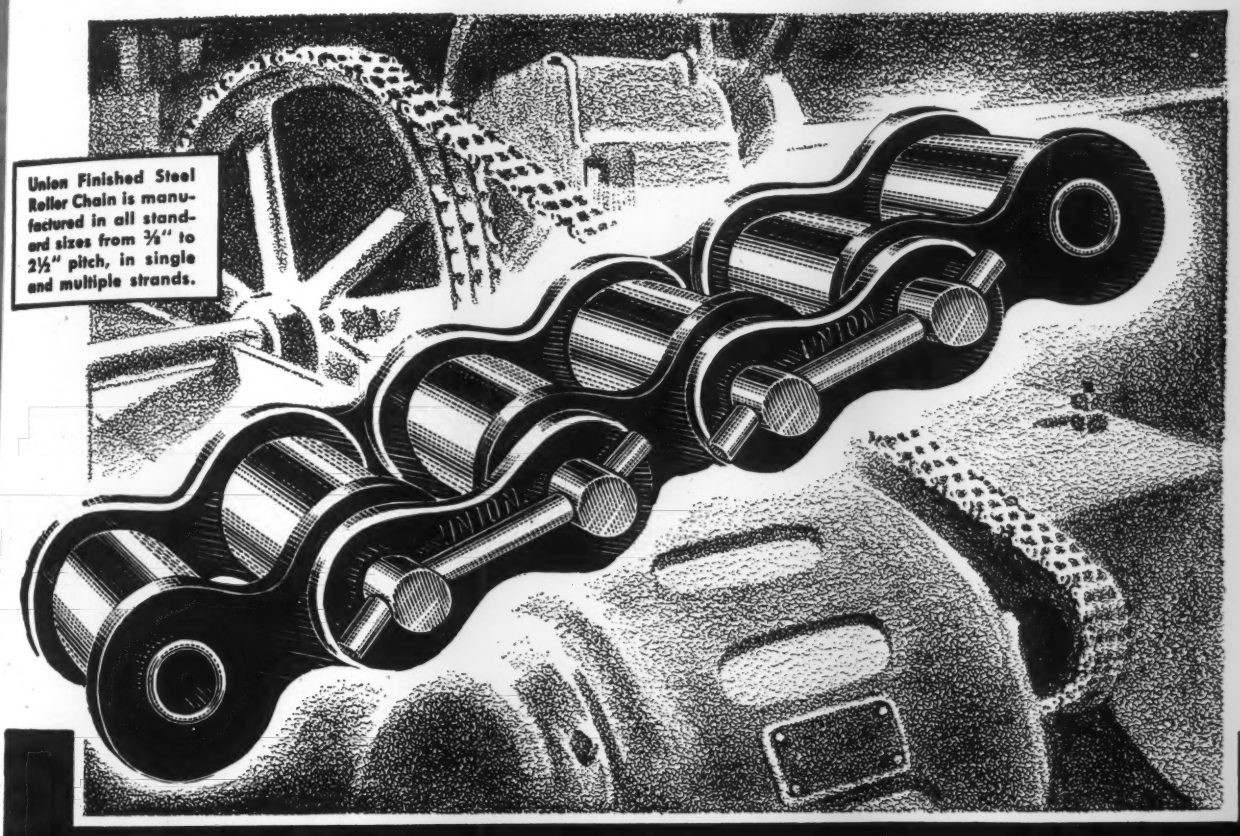
Magnesium has been an extremely active war worker. There is the wealth of knowledge gained there to guide you, plus American Magnesium's more than twenty years of working with magnesium alloys.

Achieving the ultimate in lightness is a job which magnesium does well. It weighs only one-fourth as much as the heavy metals. It has a high strength-weight ratio. If you are interested in employing this weight-saving ability of magnesium, our engineers will gladly assist you. Write Aluminum Company of America, Sales Agent for American Magnesium Corporation Products, 1703 Gulf Building, Pittsburgh 19, Penna.

MAGNESIUM MAZLO PRODUCTS

AMERICAN MAGNESIUM CORPORATION

SUBSIDIARY OF ALUMINUM COMPANY OF AMERICA

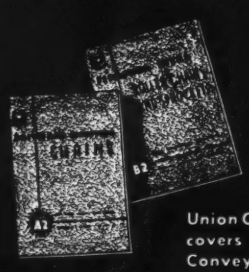


On The Job . . . To Stay

☆ Union Chains have a fine record of pleasing customers. Any buyer is naturally reluctant to try a new make of chain so long as he believes the incumbent chain in his plant or product to be satisfactory, but when such an opportunity is given, Union very frequently is "On The Job . . . To Stay!"

Why? One reason is that the entire Union Chain organization is primarily interested in manufacturing fine chain, chain attachments and chain sprockets. There may be other contributing factors, and you can find them out by trying Union as an integral part of your product or on jobs of power transmission and materials handling. Place an order with Union and judge for yourself.

The Union Chain and Manufacturing Company ..... Sandusky, Ohio, U. S. A.



Union Catalog A-2 covers Drive and Conveying Chains. Catalog B-2 covers Finished Steel Roller Chain and Sprockets. Ask for your copies

ARMY NAVY

UNION CHAINS

Union Chains for Every Application

Drive and Conveying Chains and Sprockets

- Bridge Chain
- Combination Malleable Iron and Steel Chain
- HB (hardened bearing) type chain
- BP (bar and pin) type chain

★

Finished Steel Roller Chains and Sprockets

- All manufacturer's standard, size ⅜ in. to 2½ in. pitch
- Single and Multiple Strands
- Extended Pitch Series in sizes 1¼ in. to 4 in. pitch

★

Silent Chain and Sprockets

- All sizes ⅜ in. to 1½ in. pitch

★

Flexible Couplings

- Roller chain type
- Silent chain type

THERE'S BEEN A BIG CHANGE

★ The dapple grays have disappeared from Main Street. More efficient, motorized equipment has taken over the job of fighting fires.

Tapered roller bearings have been improved, too—made more efficient by Tyson's "All-Rolls" design. Tyson's extra load-carrying rollers mean added capacity—longer bearing life—maximum rigidity.

In transportation, industry, agriculture—wherever the going is tough—Tyson's unusual performance is a matter of record.

The big name in bearings today is . . . **TYSON!**

TYSON BEARING CORPORATION, MASSILLON, OHIO

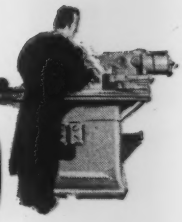
COUNT THE ROLLS · THE ROLLS COUNT

Tyson

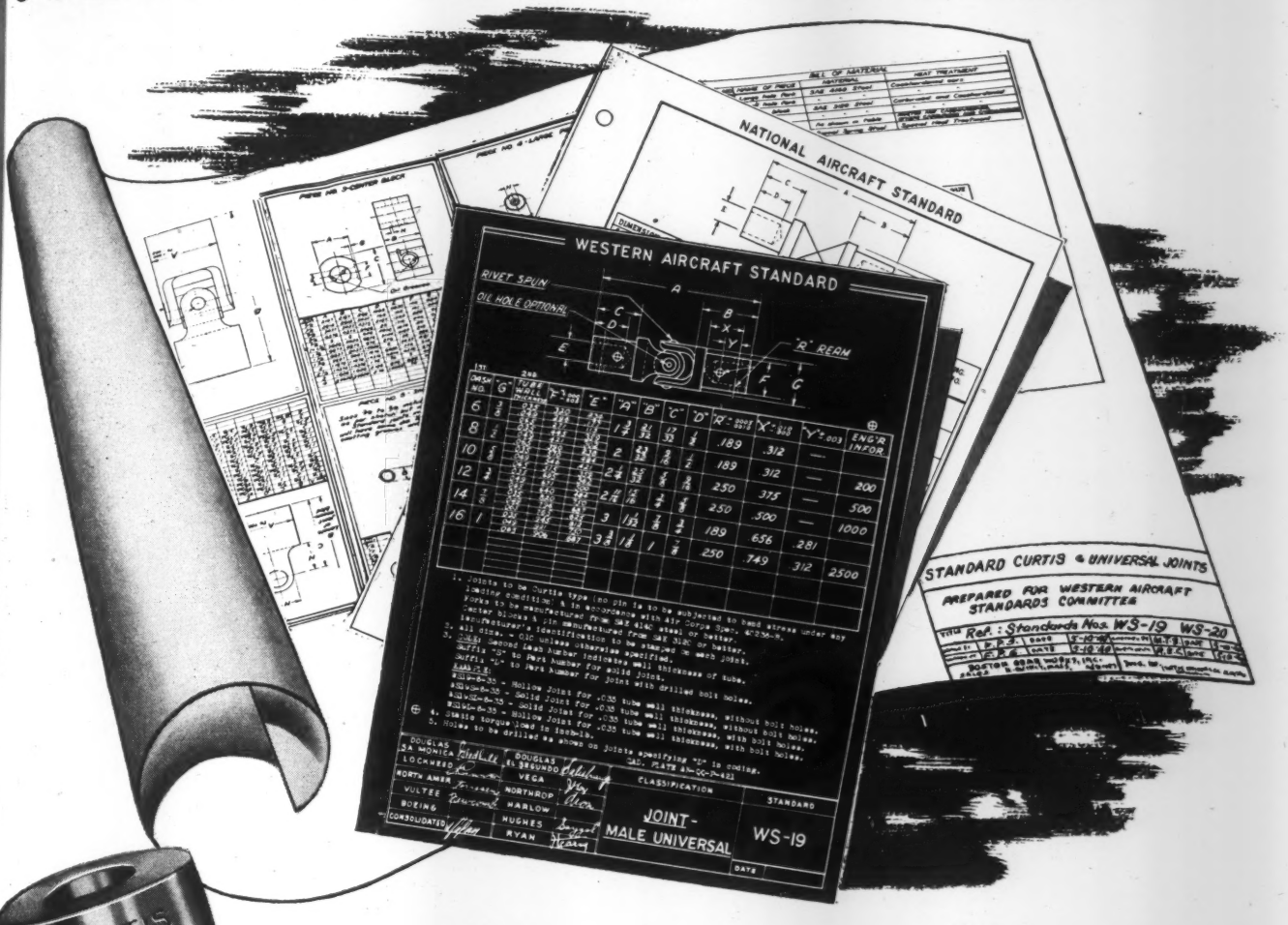
TODAY'S HEAVY-DUTY BEARING

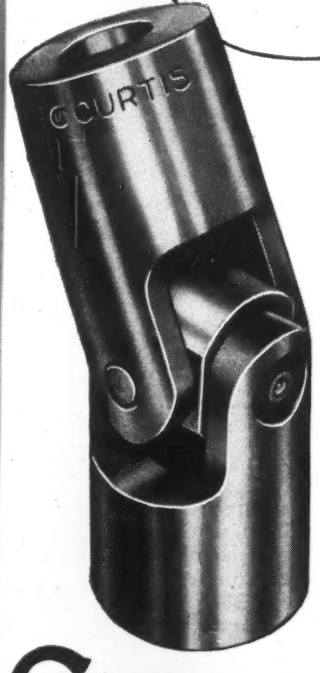
★ KEEP ON BUYING WAR BONDS ★

In the Air *or on the Ground...*



CURTIS SETS THE STANDARD





"STANDARDS" for the innumerable parts that make up a complete machine tool must be as rigid as those used in plane manufacture.

Curtis Universal Joints, made to Curtis "Standards," which have been adopted by "Aircraft Standards Committees," give manufacturers a high quality joint — a joint that meets and surpasses Army Air Corps Class 1 specifications.

Hundreds of machine tool builders have found that these joints, either single or double in any of 14 sizes, stand up under continuous operation of such equipment. Joints must be tough. Special steel alloys developed through years of Curtis production experience — careful hardening to increase toughness — accurate machining to close tolerances give smooth, hard wearing surfaces.

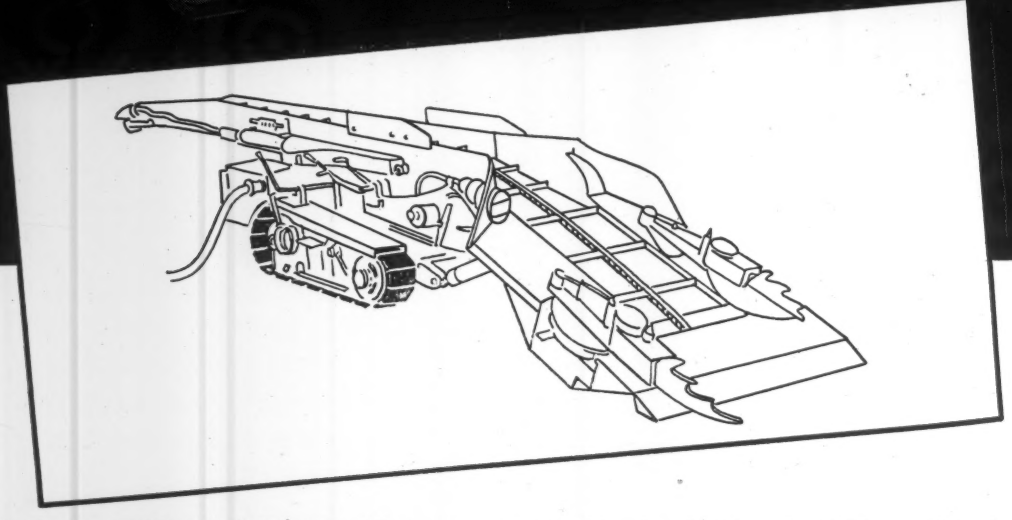
The patented Curtis "Telltale" lock ring tells you at a glance that a joint is firmly locked together — permits rapid disassembly and reassembly for inspection or repair. No screws or nuts to come loose as a result of threadwear or vibration. Curtis "Oilers" assure proper and vital lubrication.

For any and all jobs where long life and continued heavy duty are essential, choose Curtis "Standards" for your "Standards." Curtis Engineers are at your disposal to help you solve your universal joint problems.

CURTIS UNIVERSAL JOINT CO. INC.

SPRINGFIELD, MASS. • BOSTON GEAR WORKS, NO. QUINCY, MASS., SOLE DISTRIBUTORS

NO MACHINING NEEDED
FOR THIS TRACTOR SHOE
Steel Casting



● Here's more evidence of the outstanding *accuracy* and *uniformity* of Unitcastings! The steel casting shown here is a tractor shoe for a mine loading machine—by the world's largest builder of mine loading machines. The casting is used *without machining*—after drilling a hole it is ready for assembly and rugged service. Made of alloy steel...with a minimum tensile strength of 100,000 lbs. per square inch.

Unitcast has the know-how and the modern foundry facilities to assure unbeatable Quality and Dependability in steel castings. Write today...send blueprints concerning present and future needs.
Unitcast Corporation, Toledo, Ohio.

UNITCAST CORPORATION

ALLOY AND CARBON ELECTRIC STEEL CASTINGS

Design value

goes beyond

price

What does one designer build into his product that makes it sell at a profitable price, while a competing article loses money for its producer?

Little things, often hidden things. Little things that make a big difference, like Lord Shear Type Mountings of Bonded Rubber.

Where there is machinery in motion, there is vibration, and vibration means strain to machine and to man. Lord Shear Type Mountings and other bonded rubber products control and isolate vibration.

Factories that are quieter, pleasanter, more efficient; automobiles, trucks, buses, locomotives, airplanes that are smoother and safer in operation; delicate laboratory equipment that is made more accurate and trust-worthy; these are the results that Lord is helping designers and manufacturers to accomplish.

The science of vibration control and isolation has been developed by Lord for more than twenty years. This accumulated experience is available to you, without cost, whenever you are faced with a vibration problem.

Write for free literature which will bring you up to date in factual information on vibration control. Lord Vibration Engineers will work with you to bring your product to a new standard of perfection.

LORD
BONDED RUBBER
Shear Type
MOUNTINGS

Buy More War Bonds

IT TAKES RUBBER *In Shear* TO ABSORB VIBRATION

LORD MANUFACTURING COMPANY
ERIE, PENNSYLVANIA

SALES REPRESENTATIVES
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CANADIAN REPRESENTATIVES
RAILWAY & POWER ENGINEERING CORP., LTD.
TORONTO, CANADA

Originators of Shear Type Bonded Rubber Mountings

he knows how to use air—do you?

By effectively using natural air the paratrooper skillfully controls his speed and direction of descent. Compressed air, effectively used and properly controlled, does many tedious jobs for industry, saving time, labor and life or limb.

Air power is efficiently and safely handled with Schrader Air Control Products, a comprehensive line of modern air devices. Some of these products simply enable you to use air efficiently and conveniently, others boost production by eliminating slow operations. Still others reduce operator fatigue, or increase the safety of skilled fingers.

Whatever types of machines you are now operating, whatever you now make or plan to make after the war, you may be rewarded out of all proportion to cost by adding the power and versatility of air to new or war-worn machines.

For a specific example of the application of Schrader Air Control Products, look into the advantages of Schrader Hand-Operated Safety Control Sets, Foot-Operated Machine Control Sets, and Kick Press Control Sets. See your distributor or write to Schrader, Dept. D.

PROTECT SKILLED HANDS with Schrader Hand-Operated Safety Control Sets. The compressed air operates the machine while operator's hands are kept at safe distance from the danger zone. Increase production by reducing fear and fatigue. Adaptable to most presses and machines at a very moderate cost.

100th ANNIVERSARY 1844 1944

Air Valves 2, 3, 4-way • Air Operated Machine Controls
Air Operated Safety Controls • Quick Acting Couplers
Blow Guns • Air Ejection Sets • Hydraulic Gauges

Schrader
REG. U.S. PAT. OFF.
CONTROLS THE AIR

MADE BY THE MAKERS OF SCHRADER TIRE VALVES AND TIRE GAUGES

A. SCHRADER'S SON, *Division of Scovill Manufacturing Company, Incorporated,* **BROOKLYN 17, NEW YORK**

Wellman MAGNESIUM SAND CASTINGS

OFFER IMPORTANT ADVANTAGES FOR YOUR PRODUCTS ON THIS LIST*

AS you develop new products or redesign those you made prewar, keep in mind this fact: *Extreme lightness with high strength can be obtained by using Wellcast magnesium castings.* Our thirty-three years' experience, modern laboratory, foundry, and pattern shop are among the important reasons why we believe we can work advantageously with your company. Wire or write and we shall be glad to have a field engineer call.

Castings in
ALUMINUM
(Heat Treated)
MAGNESIUM
AMPCO BRONZE
BRONZE • BRASS
•
Patterns in Metal and Wood
•
WELLMAN
***Means* WELL-CAST**

THE WELLMAN BRONZE & ALUMINUM COMPANY
GENERAL OFFICES:
2547 EAST 93rd STREET • CLEVELAND 4, OHIO
CASTINGS X-RAY INSPECTED

20 TONS SUPPORTED BY ENGINEERED RUBBER

Only eight pieces of scientifically compounded rubber support 40,000 pounds!

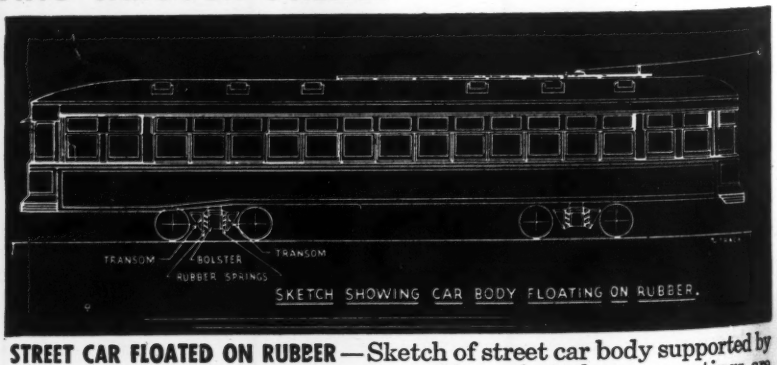
These rubber mountings were designed by United States Rubber Company to replace the leaf springs of trucks on street cars, and smooth out the ride. There is no sliding friction on such rubber springs... therefore no maintenance. Stress in all structural members above the springs is also reduced; much weight is saved through the relatively small size of the mountings.

Performance like this is responsible for the increased use of engineered rubber mountings not only on vehicles but also on a wide range of heavy industrial machines —drop hammers, lathes, blowers, and many others.

Such rubber-bonded-to-metal parts—an integral part of the structural design—cushion destructive vibration, reduce noise both inside and out and cut maintenance costs without sacrificing safety.

SERVING THROUGH SCIENCE

AFTER SIX YEARS OF SERVICE — Unretouched photograph of one of the rubber sandwiches which replaced leaf springs six years ago on a street car operating in a large Eastern city. When examined recently all were still in excellent condition.



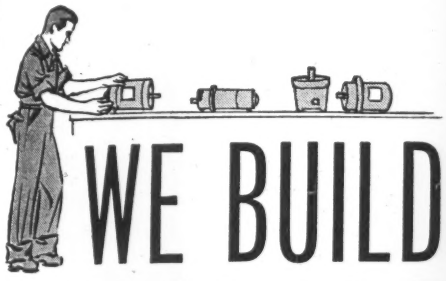
SKETCH SHOWING CAR BODY FLOATING ON RUBBER.

STREET CAR FLOATED ON RUBBER — Sketch of street car body supported by U. S. engineered rubber mountings. Note that these mountings are placed on each side of the bolster, and at both ends. The introduction of rubber as a structural part of heavy vehicles has done much to minimize noise, vibration, and shock not only on street cars but on railway cars, trucks and busses.

Listen to the Philharmonic-Symphony program over the CBS network Sunday afternoon, 3:00 to 4:30 E.W.T. Carl Van Doren and a guest star present an interlude of historical significance.

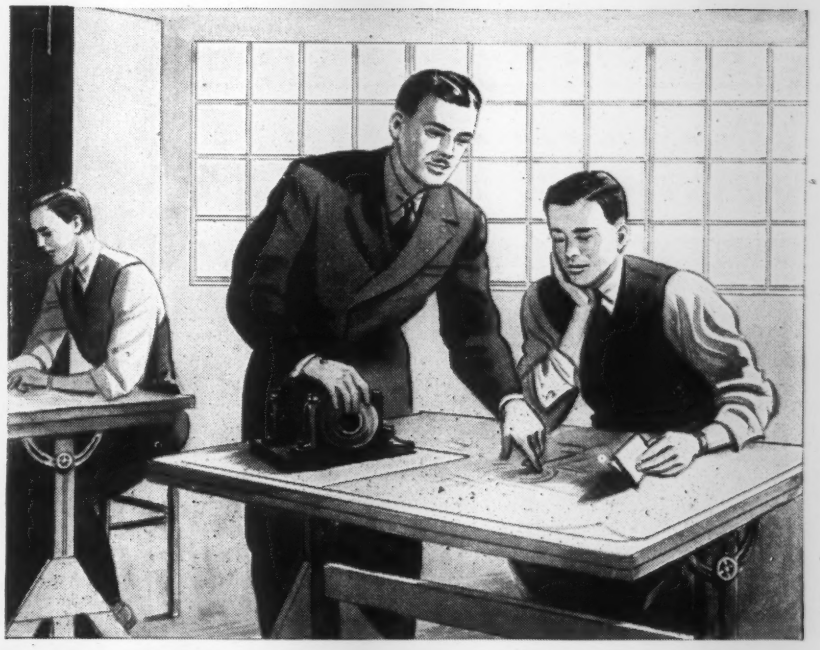
UNITED STATES RUBBER COMPANY

1230 Sixth Avenue • Rockefeller Center • New York 20, N. Y. • *In Canada:* Dominion Rubber Co., Ltd.



WE BUILD MOTORS

to Conform to



YOUR MACHINE DESIGN

Design and build your machines to suit their functional requirements and don't worry about the electric motors required to power them. Because that is our job.

We specialize in building "Custom-built" Motors of every description. They're built to *conform* to the machines, and they do a very efficient and outstanding job of powering them. So let yourself go in designing your machines. We'll build for you the special motors that will conform to those designs.

You'll be particularly pleased with the *Inter-changeable Feature* of Welco Torque Motors, because the Welco A.C. motor will fit where the D.C. motor fits, and vice versa. This exclusive feature is particularly valuable to the machine builder whose designs conform to the modern trend of built-in construction and remote control.

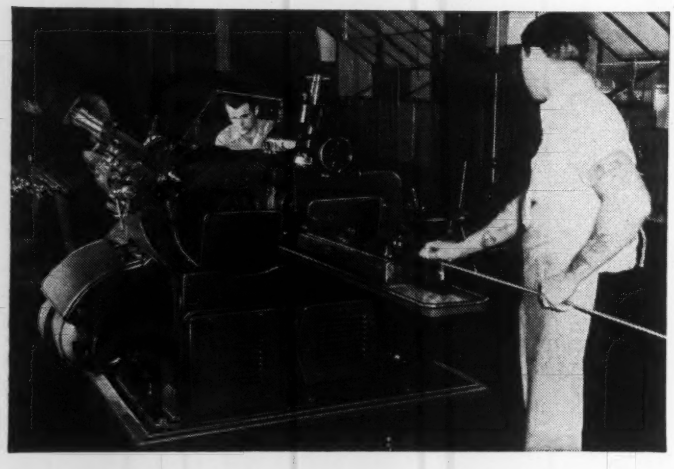
For thirty-five years specialists in custom-built torque motors, any size up to 75 H.P. for any application.

Write for full details

THE B. A. WESCHE ELECTRIC CO. . . . CINCINNATI 10, OHIO

PRECISION PARTS

ACCURATE TUBING STARTS HERE



Dangerous errors in instrument readings can be caused by irregularities on the inside surface of tubing. Ace precision ground steel mandrels help keep this surface accurate in all kinds of glass, fibre, rubber, and plastic tubes.

The Ace battery of centerless grinders offers economies in the production of mandrels from .030″ to 6.00″ in diameter, and in lengths up to 20 feet. Diameters are held within .0005″. They are round to within .0002″. And Ace can hold them even closer where necessary.

Ace offers manufacturers today a complete service for producing small parts and assemblies. Here under one roof is the modern equipment, the ability to do fast, accurate work involving stamping, machining, heat-treating, or grinding.

Send blueprint, sketch, or sample for quotation.

CURRENT CAPACITY AVAILABLE

CYLINDRICAL GRINDING—Multiple banks of widely varying internal and external cylindrical grinders are available for outside diameters up to 12″ by 24″ between centers . . . and inside diameters as small as 1/16″ or as large as 4″ by 2¼″ long.

THREAD GRINDING—Our battery of Ex-Cell-O Thread Grinders equips us to give you tolerances of .0001″ on all Standard V Threads, Acme and Square Threads, and on single or multiple leads. All sizes up to 5″ diameter with threads 8″ long, on parts up to 20″ between centers.

ACE
TRADE MARK

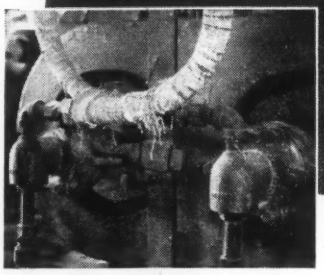
ACE MANUFACTURING CORPORATION

for Precision Parts

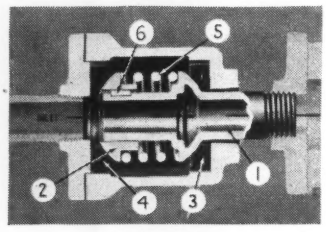
ARMY E NAVY

1201 E. ERIE AVE., PHILADELPHIA 24, PA.

Can you use a Stuffing Box that's PACKLESS SELF-OILING SELF-ADJUSTING SELF-ALIGNING



• Johnson Joint on rubber mill



• Nipple (1), fastened to roll or drum. Sliding collar (2), keyed (6) to nipple. Carbon graphite seal ring (3) and bearing ring (4) eliminate oiling and packing. Spring (5) is for initial seating only; joint is pressure sealed.

IF you have a problem that has to do with getting steam, or liquids under pressure, into rotating machine parts, don't overlook the possibilities of the Johnson Rotary Pressure Joint.

It is being used on Paper Making and Textile machinery, in cold strip steel mills, on machine tools, and for an increasingly wide range of other applications. So completely does it outmode the old style stuffing box that industry has already adopted over 50,000 Johnson Joints in the few years since their development.

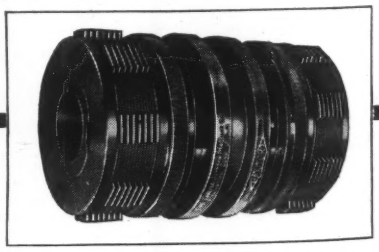
Write for complete information

The Johnson Corporation

811 WOOD STREET JC **THREE RIVERS, MICH.**

"MAXITORQ"... manual assembly and adjustment

YOU NEED NO TOOLS



This is the last word in smooth, trouble-free clutch operation . . . especially for machine tool power transmission where fast acceleration of pick-up and positive disengagement are vitally essential. Multiple floating discs ride free in neutral . . . no re-engagement, no drag, abrasion or heat.

INSTALLATION, ASSEMBLY and **ADJUSTMENTS** are all made to hold securely, without tools.

Single and double clutches are available in both wet and dry types . . . capacities ¼ to 5 H.P. at 100 R.P.M. Also in Pulley and Cut-off Coupling types.

"Maxitorq" clutches are highly respected by nationally known machine tool manufacturers who depend upon their reliability for the operation of important machinery.

MAXITORQ *floating* **DISC CLUTCH**

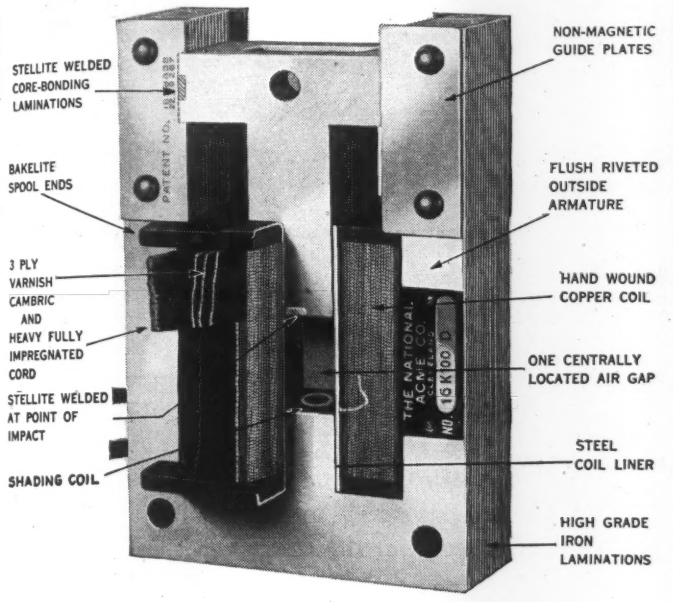
Ask for CATALOG NO. 4

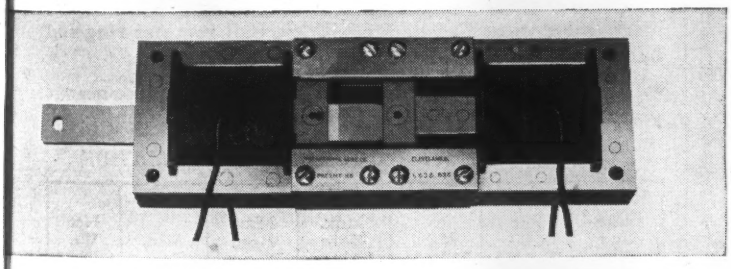
THE CARLYLE JOHNSON MACHINE COMPANY

•

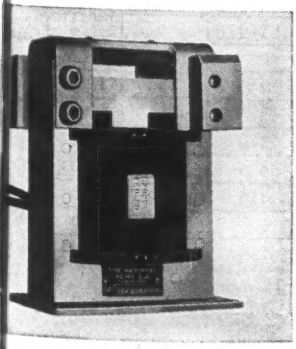
MANCHESTER, CONN.

ANSWERS TO QUESTIONS ABOUT *Solenoids*

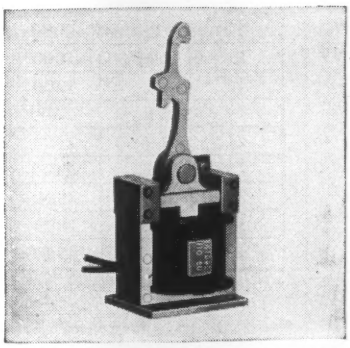




Double Solenoid for forward and reverse of hydraulic valve.



Valve operating Solenoid with leather-faced plunger stop.



Ratchet indexing Solenoid used in Electric Counters.

1 Solenoids make use of the electromagnet principle to operate devices that require *push* or *pull* motion.

2 The Solenoid principle is not new, but war production has developed many important new applications.

3 Some of the uses of Solenoids—many of them presenting new and original engineering—that have been developed by National Acme are:

Actuate clutches
Operate switches
Machine controls
Gun firing mechanisms
Operate safety devices
Eject work in process
Clamping devices
Move levers
Operate valves
Vibrate cutting knives
Open and close doors
Holding chucks
Hopper opening and closing
Sorting inspected parts

4 Solenoids are space-saving, dependable, easy to install, can be remote-controlled, often eliminate more complex mechanisms and make machines more automatic.

5 National Acme engineers design and build a wide variety of Solenoids in capacities from 4 to 35 lbs. push or pull.

Inquiries involving special problems that arise from your new designs, or for more dependable performance on old applications, are welcomed.

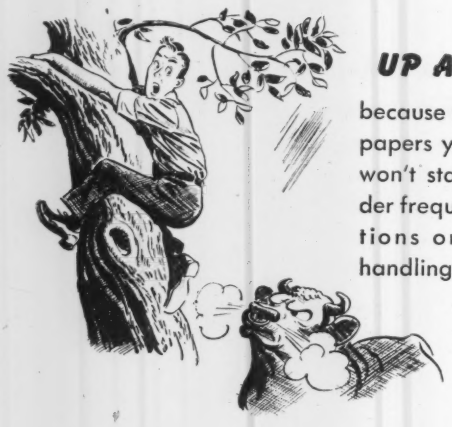
For standard Solenoids, ask for Bulletin EM-41.

ELECTRICAL MANUFACTURING DIVISION

THE NATIONAL ACME CO.

170 EAST 131ST STREET • CLEVELAND 8, OHIO

ACME-GRIDLEY 4-6 AND 8 SPINDLE BAR AND CHUCKING AUTOMATICS • SINGLE SPINDLE AUTOMATICS • AUTOMATIC THREADING DIES AND TAPS
THE CHRONOLOG • LIMIT, MOTOR STARTER AND CONTROL STATION SWITCHES • SOLENOIDS • CENTRIFUGES • CONTRACT MANUFACTURING



UP A TREE

because the tracing papers you use just won't stand up under frequent corrections or constant handling?

PUT A BEE

in your boss's bonnet to give tracing papers the old heave-ho, and to switch to tracing cloths . . . *Arkwright Tracing Cloths!*

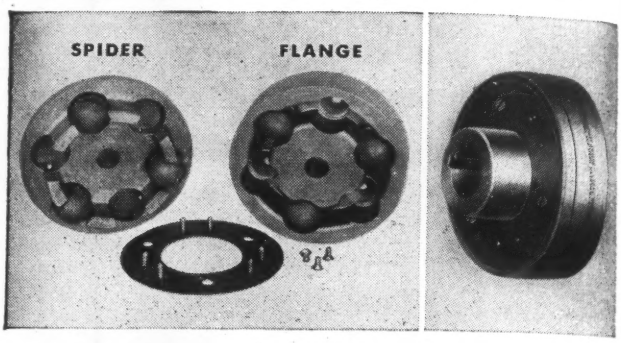
YOU'LL SOON SEE

that frequent corrections and constant handling don't hurt Arkwright Tracing Cloths a bit. In the long run, you'll also see they cost no more than tracing papers. Arkwright Finishing Company, Providence, R. I.

Sold by leading drawing material dealers everywhere

Arkwright
TRACING CLOTHS
AMERICA'S STANDARD FOR OVER 20 YEARS

Simplify assembly with . . .



CUSHIONPOWER
RESILIENT FLEXIBLE COUPLINGS

1—Easy to assemble . . . only a screw driver required.
2—Easy to line up with a straight edge.
3—Easy to disconnect without changing alignment.
4—No lubrication or maintenance required.
5—Absorbs load shocks.
6—Reduces wear in connected machines.
7—Cushions noise and vibration.
8—Trouble-free operation.

► These flexible couplings, made by the makers of Crocker-Wheeler Motors and Generators, are available for every coupling application. The simple, efficient, economical **CUSHIONPOWER** coupling is not only flexible, but resilient.

► The coupling is simple in design, having but four mechanical parts . . . flange, spider, ball retainer ring and balls moulded from a special rubber composition.

► Write for complete information or call our office nearest you . . . see list below.

CUSHIONPOWER COUPLING INFORMATION

Coupling Size	*H. P. Per 100 R. P. M.	Max. R. P. M.	Max. Bore Spider	Max. Bore Flange	Min. Bore	Net Wt. Lbs.
6	½	7000	¾	1¼	½	3
9	1¼	5000	1¼	1½	¾	6
10	1	7000	1¼	1¼	½	4
11	2½	4000	1⅝	2	⅞	12
16	5	3200	2	2½	1⅛	25
19	11	2600	2⅜	3	1½	40
21	14	2300	2⅝	3¼	1¾	65
25	20	2100	3⅛	4	2	90
27	25	2000	3⅜	4½	2¼	110
31	35	1800	3⅞	5	2½	170
35	55	1550	4½	5½	2½	300

** Use for all applications . . . no service factor necessary.*

JOSHUA HENDY IRON WORKS
CROCKER-WHEELER DIVISION
AMPERE, NEW JERSEY

BOSTON • BUFFALO • CHICAGO • CINCINNATI • CLEVELAND • LOS ANGELES
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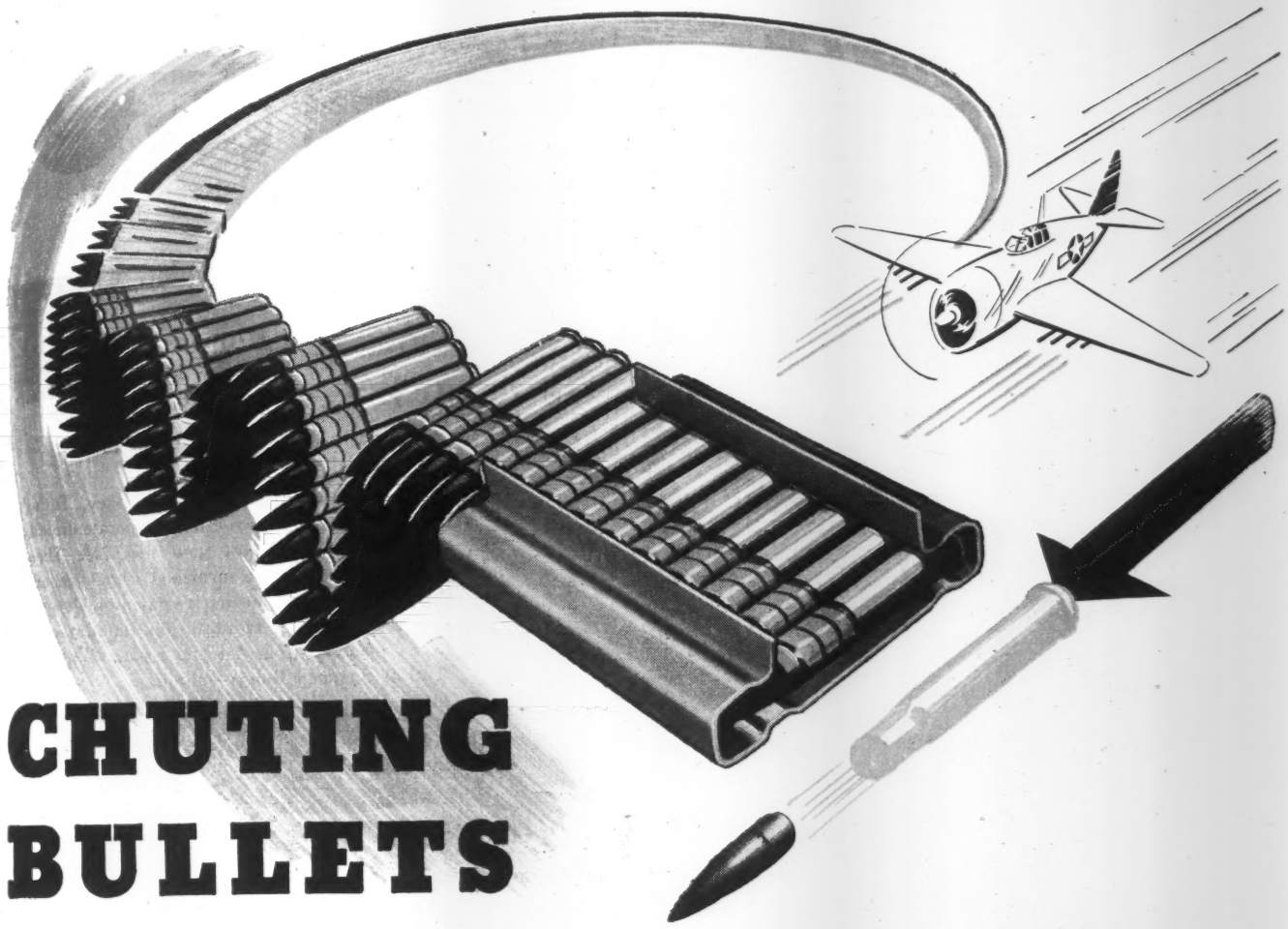


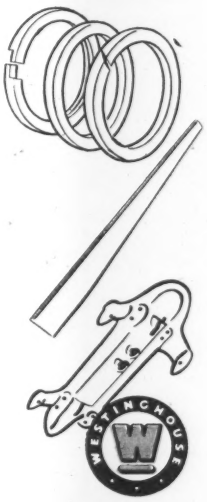
CHUTING BULLETS

into firing position with strong, lightweight

PUMP RINGS made of Micarta do not soften in service, wear slowly, and will not score cylinder walls.

ANTENNA MASTS of Micarta hold the antenna taut without yield or wobble . . . withstand wide extremes of pressure and temperature.

BOMB RACKS have been successfully molded of Micarta . . . furnish an excellent example of Micarta's strength and the skill of Westinghouse engineers in intricate molding assignments.



Micarta

MICARTA

Another example of versatile Micarta *at work*

Bullets for a plane's chattering wing-guns are stored in long, looping belts. To guide each bullet accurately into firing position, plane makers are now using chutes formed of *MICARTA—"444"*, the light, strong sheet plastic. Here's why:

MICARTA weighs approximately one-half as much as aluminum of equal strength—helps eliminate superfluous weight in the plane.

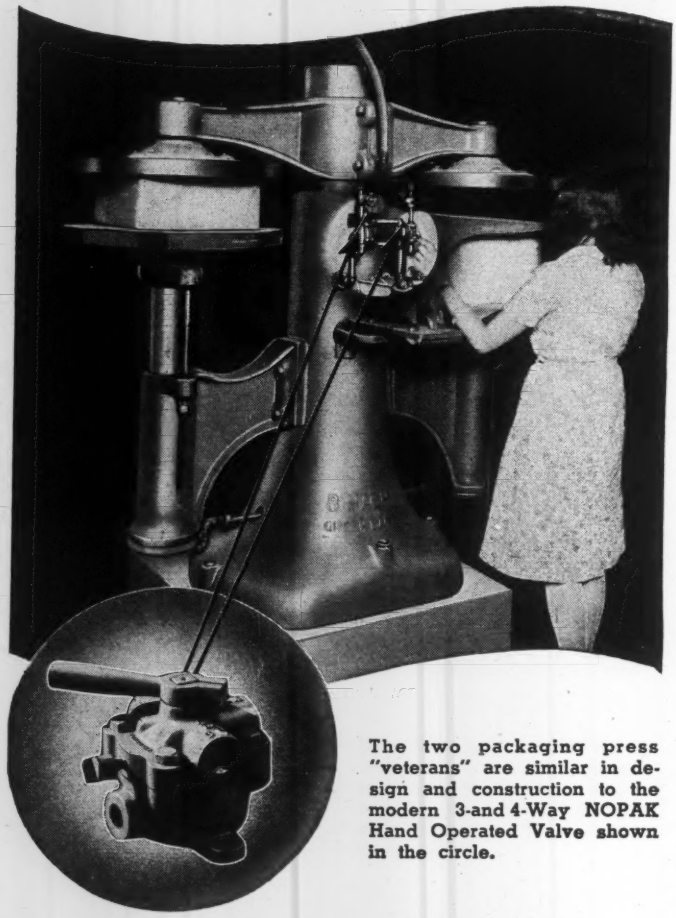
MICARTA rates high in flexural, compressive and impact strength. In high altitude flying, as temperatures decrease, Micarta acquires added tensile strength.

MICARTA "444" is easily and quickly produced with inexpensive wooden molds. Sheets are subjected to heat and pressure, and formed into strong, intricate shapes.

This new, Micarta "444" is now accepted for use as trim tab fairing, accumulator covers, aviator's chart cases, fuselage tail-wheel housing, wing-gun ejection chutes. For further information and your copy of the new Micarta Data Book, B-3184-A, write Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., Dept. 7-N.

J-06346-A

Specify NOPAK for LONG VALVE LIFE



The two packaging press "veterans" are similar in design and construction to the modern 3-and 4-Way NOPAK Hand Operated Valve shown in the circle.

OVER 10 YEARS CONTINUOUS SERVICE WITHOUT MAINTENANCE EXPENSE

The two NOPAK ¼", 3-Way Air Valves on the packaging press shown above, have been in daily use for over ten years without a single day off for repairs or maintenance. After 10 years they are still leak-proof, show no visible signs of wear.

This is the kind of long term, maintenance-free operation you can expect from NOPAK Valves. It is the inevitable result of the patented cored-disc principle, hand-lapped, wear-proof disc and seat, shielded sealing surfaces, packless valve stem assembly . . . features which contribute to their simplified design and extremely rugged construction.

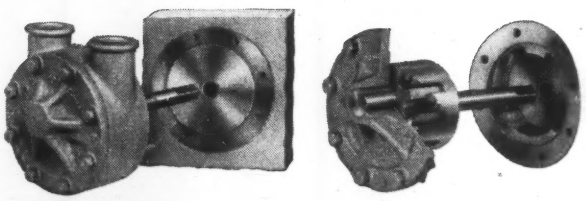
You can specify NOPAK Air or Hydraulic Valves as component parts of your product with absolute assurance that their dependable performance and long service-life will match that of the equipment on which they are used.

Write for Bulletin 88.

GALLAND-HENNING MFG. CO.
2752 S. 31st STREET MILWAUKEE, WISCONSIN
Representatives in Principal Cities

NOPAK VALVES and CYLINDERS
DESIGNED for AIR or HYDRAULIC SERVICE

A 4553-½



STRIPPED . . . for Action and Economy

how TUTHILL PUMPS can be built into the design of your machine

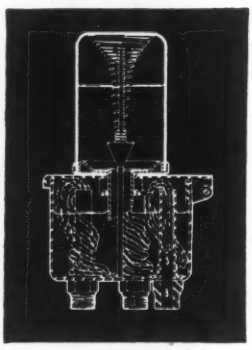
To save space, material and money, Tuthill builds stripped pumps for you to incorporate directly into the design of your machine. These internal-gear rotary pumps are furnished without mounting bracket or without housing as pumping elements —for coolant, lubrication, hydraulic and liquid transfer service. Capacities from 1 to 50 g.p.m. Write for Tuthill Stripped Pump Bulletin.

★

Tuthill Pumps are serving Army • Navy Air Force • Merchant Marine and Industry

TUTHILL PUMP COMPANY
939 East 95th Street • Chicago 19, Illinois

Lubricate...

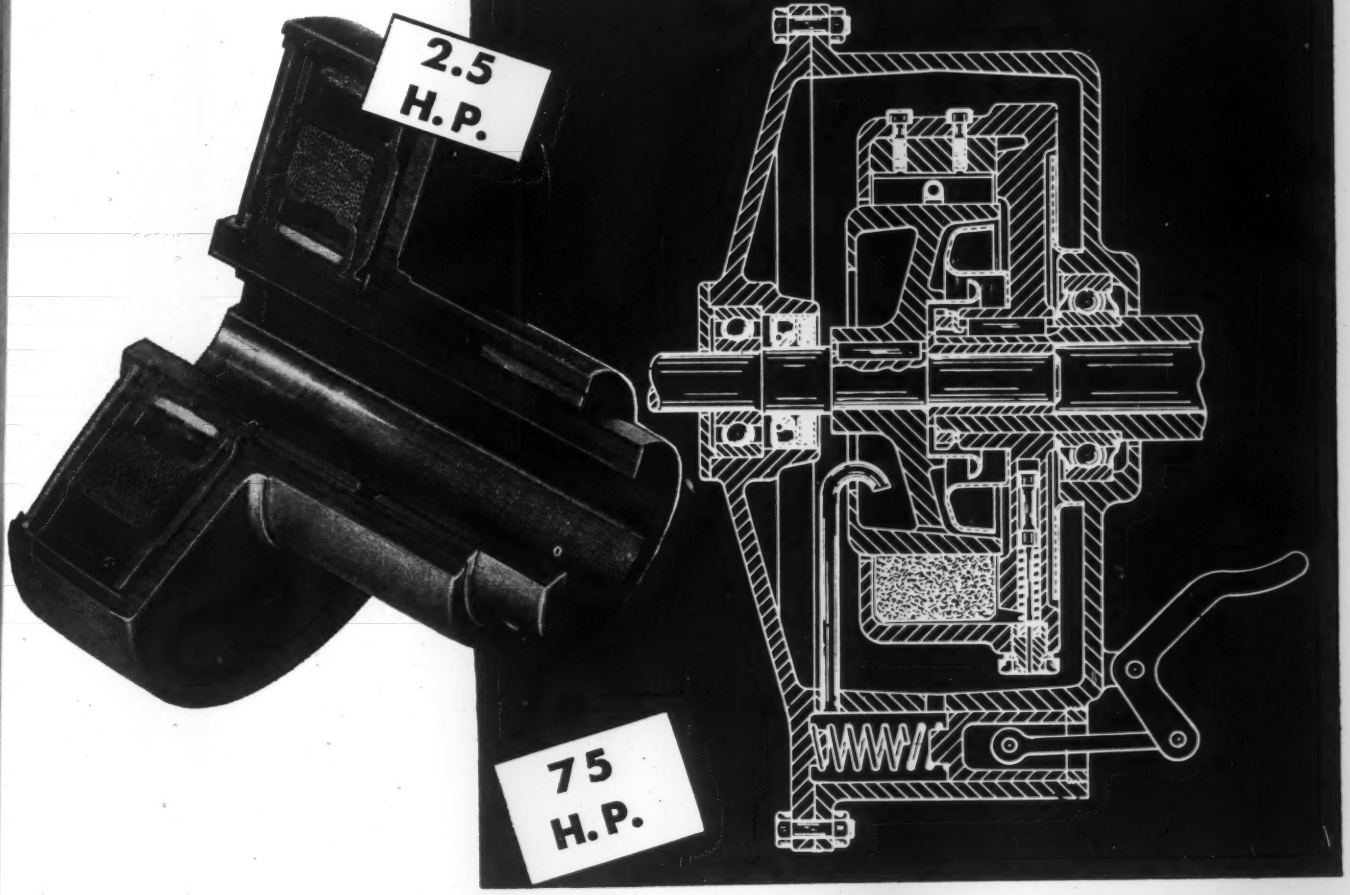


MULTIPLE POINTS
with Constant-Flow, Filtered Oil, from a Central Location

The Gits "MWA" Multiple (Constant Level) Wick Feed Oiler provides a definite saving over the cost of individual oilers. The transparent top, or secondary oil reservoir not only provides an additional supply of oil, but enforces a constant level of oil in the primary reservoir with the result of positive, even flow of oil through the wicks to all leads. The capillary action of the wick will not and cannot transport impurities and sediment—therefore, only filtered oil reaches bearings. The Gits "MWA" Oiler is available in a wide range of capacities and number of leads. Request Catalog No. 60 for complete information on this and other Gits Oilers, Oil and Grease Seals and Lubricating devices.

GITS BROS. MFG. CO.
1868 South Kilbourn Avenue • Chicago 23, Illinois
Exclusive for over 35 years

POSITIVE TORQUE CONTROL



Less H.P. *plus* a Mercury Clutch starts the load . . .

An analysis of the starting torque requirements to bring any power driven load from a standstill to operating speed reveals that the power required to overcome the "break-away" friction and the power required to accelerate the inertia load almost always exceed by a wide margin the power required to maintain full operating speed under load.

When used between the prime mover and the load, the inherent characteristics of the Mercury Clutch make it unnecessary to overpower the equipment to get it started or resort to special motors and expensive starting devices.

The Mercury Clutch permits the motor to come up to full operating speed, before the load is applied, and applies the load gently to take full advantage of peak motor efficiency. *RESULTS* . . . Smaller and less costly motor . . . Greatly reduced starting current . . . Better power factor . . . Lower connected load . . . Overload protection.

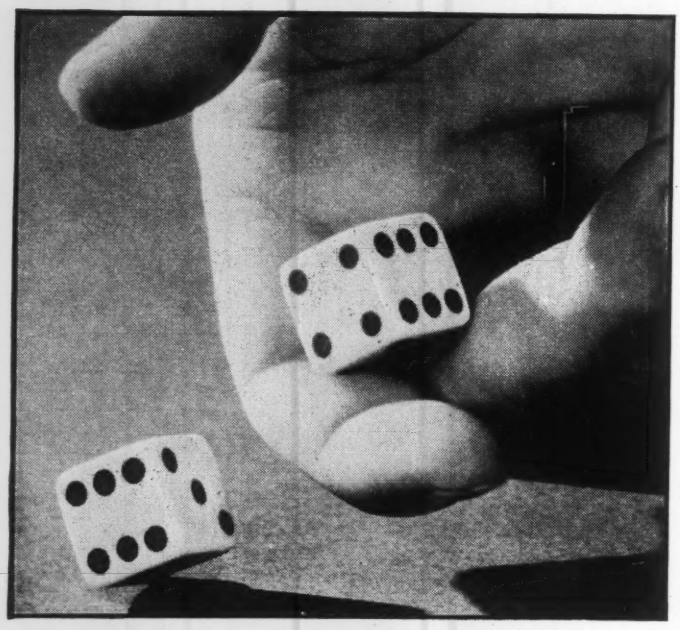
The exclusive and unique feature of the Mercury Clutch is the use of Mercury, the liquid metal, as the control medium. Mercury, acted on by centrifugal force, controls the action of the clutch. The effective pressures created can be brought to bear at any desired point without levers or other mechanical means.

MERCURY CLUTCH CORPORATION

New York Office:
19 Rector Street

2030 Deuber Ave., S. W. CANTON · OHIO

WHY GAMBLE?



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"SAFETY PLUS" SOCKET SCREWS

are accurate to the Nth degree

When purchasing socket screws, why gamble with products of inferior quality? Since 1872, the name Chicago Screw Company has meant precision and quality. Our complete Chicago "Safety Plus" line of Socket Screw Products are not only accurate, but they are tough and strong.

This great line includes Socket Head Cap Screws, Socket Set Screws, Socket Pipe Plugs, Socket Stripper Bolts and Square Head Set Screws.

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ARMY E NAVY

These Fine Products are sold only thru Authorized Distributors

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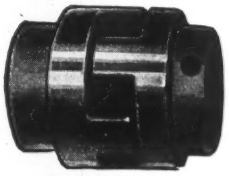
PROTECT MACHINERY for *Today's* Production Demands!

L-R FLEXIBLE COUPLINGS

"Resilient Alignment" Type most efficiently correct for misalignment, take up whip, backlash and overload. Non-Lubricated. No shut-downs for change. Quiet.

L-R TYPE "IA"

For 1/6 to 50 h.p. Only 3 parts—2 metal bodies and resilient spider. In widest use for small pumps, fractional h.p. motor, fan and air-conditioning, a multitude of uses.



LR TYPE "IA"
Pat. and Pats. Pend.

Send for L-R Selector Charts with complete Catalog

Catalog shows L-R couplings for every duty to 2500 h.p. Simplified Charts lead you at once to couplings for your exact purposes. All engineering data and information right at hand. L-R Charts are time savers which should be in every engineer's file.

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Plastic MOLDING SERVICE

Through years of experience, the Standard Products Co. has acquired a wealth of knowledge in the art of molding plastics. Standard offers complete molding service.

Standard's molding equipment is capable of producing items of phenolic cellulose-acetate, butyrate, polystyrene, ethocel and other plastic and thermoplastic materials. These facilities assure perfection in the molding job.

The Standard Products Co., with its great resources, can do your job quickly and effectively at moderate cost. Let us have the necessary data and our engineers will submit designs and proposal.

THE STANDARD PRODUCTS COMPANY

General Offices and Research Laboratory

505 Boulevard Bldg. • Woodward Ave. at E. Grand Blvd. • Detroit 2, Mich.

OHIO Small MOTORS

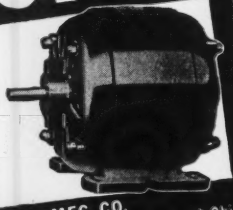
VERSATILE and EFFICIENT

● For general purpose applications. Split capacitor type..1400 to 3400 RPM ..1/80 to 1/20 HP..Voltages up to 220 AC..60, 50 and 25 cycles..bases solid, resilient or flange for horizontal, sidewall, ceiling or vertical mountings, shaft up or down.

What is Your Problem?

THE OHIO ELECTRIC MFG. CO.
5906 Maurice Avenue, Cleveland, Ohio

OHIO TORQUE MOTORS



● Will rotate slowly or stand stalled exerting full torque without overheating for any time cycle. Ball bearing and quiet operating. Built for multiple or single phase a.c., and for direct current. Sizes to exert torque from 1 oz. ft. to 100 oz. ft. equal to 1/16 ft. lb. to 6¼ ft. lb.

WHAT IS YOUR PROBLEM?

THE OHIO ELECTRIC MFG. CO.
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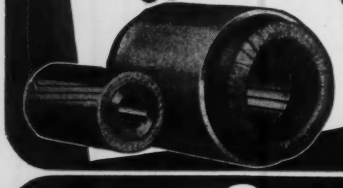
OHIO Shell-type MOTORS

COMPACT and EFFICIENT



● Stator is pressed into a heavy steel shell and rotor is bored to be mounted on spindle. Stator and rotor are machined to very close limits. Ratings from ¼ to 5 HP—1150, 1750 and 3500 RPM., 110, 220, 440 & 550 V. polyphase.

THE OHIO ELECTRIC MFG. CO.
5906 Maurice Avenue, Cleveland, Ohio

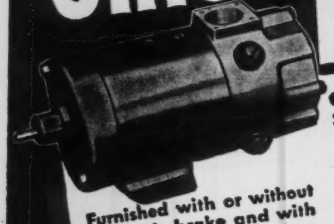
OHIO INTEGRAL MOTORS

● Fully enclosed. Rotor dynamically balanced. Runs quietly with minimum vibration. 2 or 3 phase, 60 or 50 cycles; voltages, 110, 220, 440 and 550; sizes ½ to 2 HP. Speeds from 860 to 3500 RPM. Odd voltages and cycles also available.

WHAT IS YOUR PROBLEM?

THE OHIO ELECTRIC MFG. CO.
5906 Maurice Avenue, Cleveland, Ohio

OHIO AIRCRAFT MOTORS



Furnished with or without magnetic brake and with or without cooling fan.

● Can be supplied as follows: Speeds up to 7500 RPM. Voltages 12 or 24 volts, DC. HP range 1/100 to ⅓ HP. Weight and length vary with HP and speed. Mounting and shaft to specifications.

THE OHIO ELECTRIC MFG. CO.
5906 Maurice Avenue, Cleveland, Ohio

Points for Designers about the

"FLEXLOC" STOP and LOCK NUT

Pat. Applied for

- It is of one-piece construction
- Every thread—including locking threads—takes its share of the load. Its height can therefore be made the same as that of the corresponding-size commercial nut, without sacrificing any load capacity or locking ability—a feature which saves both valuable space and weight.
- It can be made of any of the conventional nut materials
- Its construction is especially advantageous for thin nuts
- It accommodates itself to a very wide range of thread tolerances
- It can be used again and again without losing its ability to lock
- Being a "stop" nut, it stays in any position on a threaded member
- Sizes from No. 6 to 1" diameter. Millions in use. Write for Bulletin 582.

ARMY E NAVY

OVER 40 YEARS IN BUSINESS

STANDARD PRESSED STEEL CO.

JENKINTOWN, PENNA. BOX 102

—BRANCHES—

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ABART Speed Reducers. Over 75 types and sizes. Ask for Speed Reducer Catalog.

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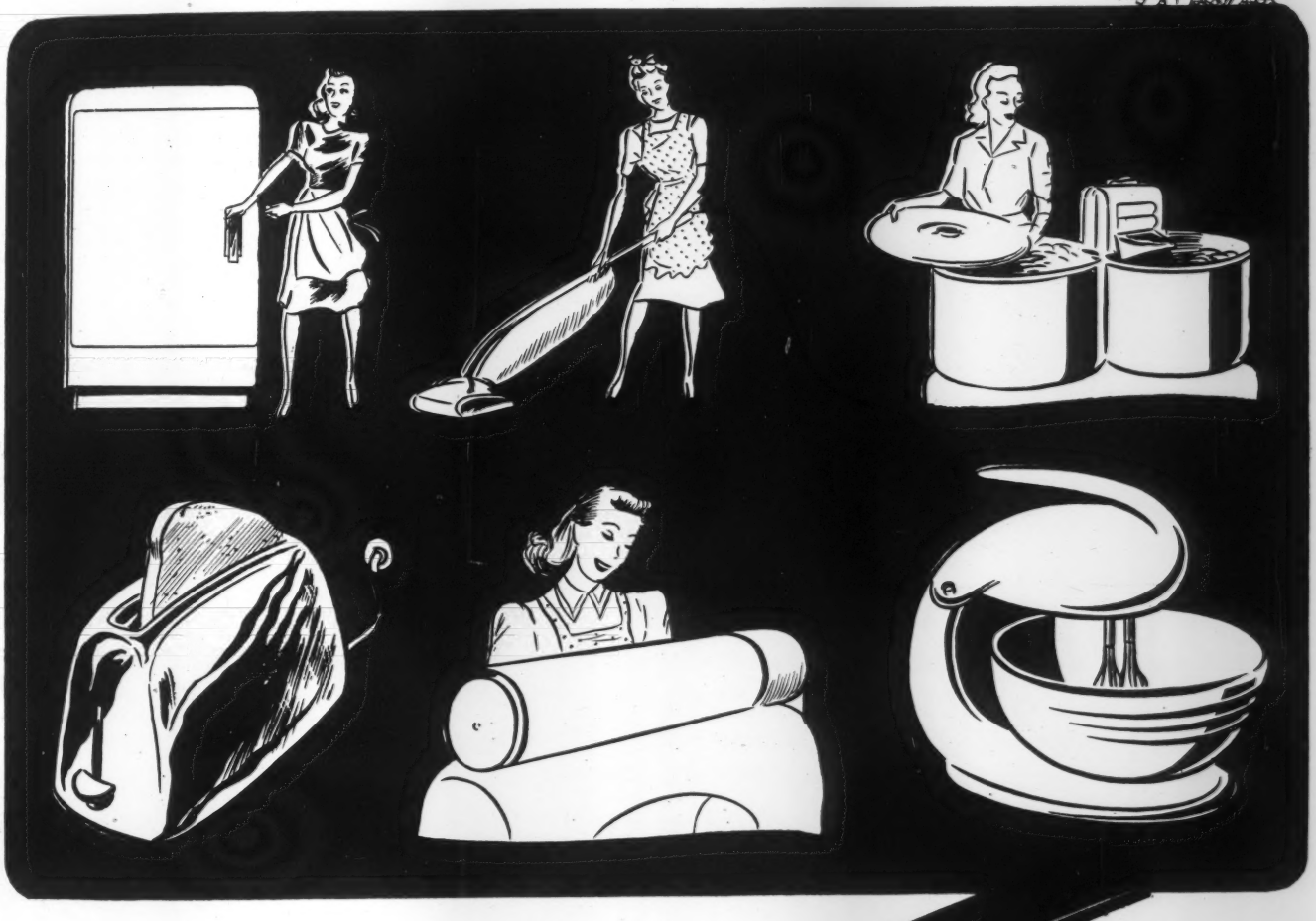
GEAR & MACHINE CO.
Manufacturers of Speed Reducers and Gears
4821 West 16th St., Chicago 50, Ill.

GRAPHITAR Bearings, Vanes and Moving Parts

(CARBON-GRAPHITE)

~~Make~~ Household Appliances Work *Quietly*



GRAPHITAR, the non-metallic carbon-graphite material has many unusual properties which make it efficient for decreasing friction, maintenance and, especially, noise in household appliances. Small bearings, vanes, pistons and seals made of Graphitar have greatly improved the quietness of operation of toasters, refrigerators, vacuum cleaners, washing machines and mangles.

Graphitar is chemically inert. It effectively resists acids, gases, and chemicals of all kinds. Self lubricating, Graphitar has a low coefficient of friction. Graphitar parts take on a high polish and operate indefinitely with little or no lubrication.

Graphitar is mechanically strong yet extremely light. Its lightness approaches that of magnesium. Manufactured in several basic grades, Graphitar may be ground to tolerances as close as .0005" on small sizes.

In scores of widely varied consumer and industrial products, Graphitar has proven its worth. Write today for 24 page illustrated book of facts.

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THE UNITED STATES GRAPHITE COMPANY • SAGINAW, MICHIGAN

Why doesn't it fall?

The fulcrum of this remarkable rock formation is 100% right in design. The instant it ceases to be so, Idol Rock will crash!

Often in product design, a very small part is entrusted with great responsibility—sometimes with the successful operation of the product itself. When required, "Peck Service" supplies such important parts in long runs of precision accuracy . . . is doing it now for Uncle Sam . . . had been doing so during many peace-time years.

If your postwar plans would be benefited by carefully made screw machine products up to 1¼" size or by springs up to ⅛" wire size, contact us now. We'll be glad to collaborate with you in advance of the actual need.

Idol Rock, Brimham, Yorkshire, with base sandblasted by Nature to nearly the vanishing point!

Peck SPRINGS & SCREW MACHINE PRODUCTS

THE PECK SPRING CO., 10 WELLS ST., PLAINVILLE, CONN.

Cramer

Percentage Timers

Type PT

Automatically controls the percentage of time at which any AC electrical circuit can be closed or opened out of a definite length of time.
Used for regulating heat input for small electric furnaces, ovens or heaters; to control the proportionate flow of chemicals for treatment of boiler feed water and other industrial processes.

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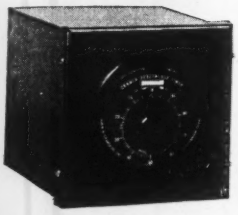

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CENTERBROOK CONNECTICUT

. . THE MOST BRILLIANT NAME IN LEAD PENCILS . .

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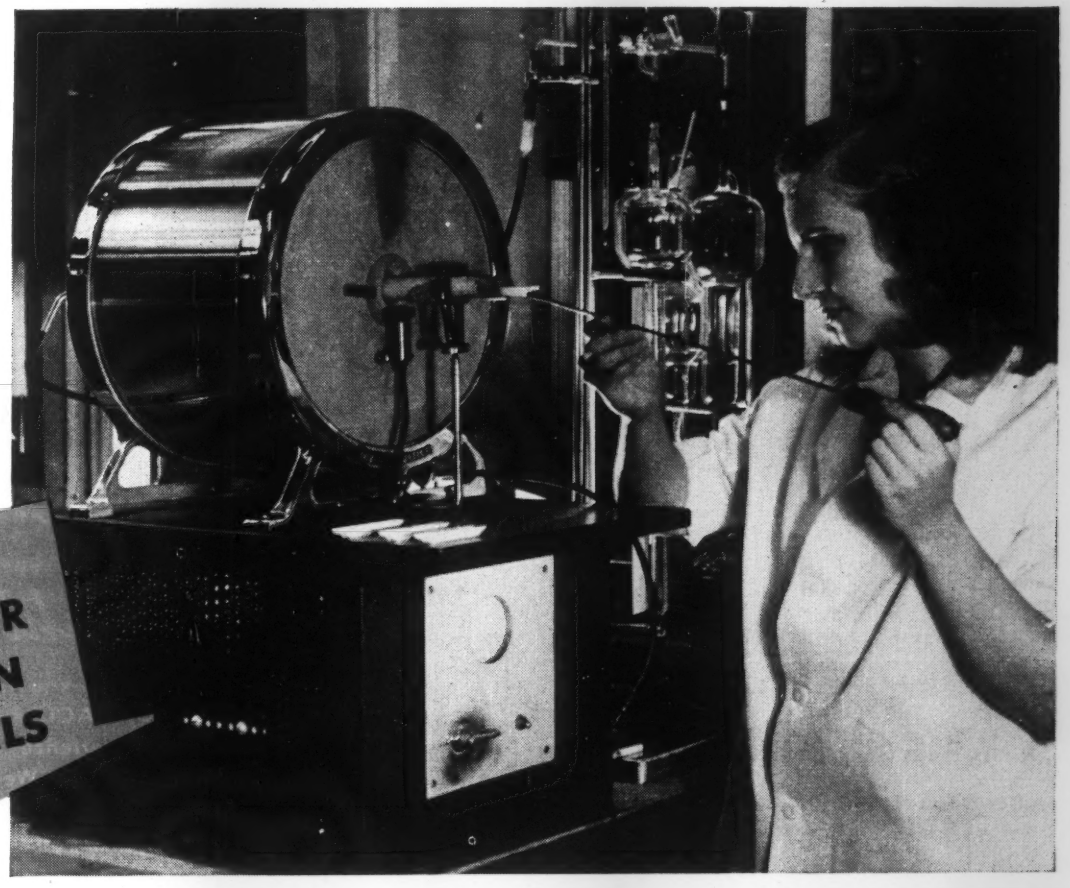
Like the WORLD FAMOUS KOH-I-NOOR DIAMOND, KOH-I-NOOR PRODUCTS have long been famous for their outstanding qualities. Whatever is required in pencil performance will be found in our exceptional quality lines.

Send for your copy of our catalog

KOH-I-NOOR PENCIL COMPANY, INC.
BLOOMSBURY, N. J.



...are being perfected NOW!

MEASURING the exact amount of carbon in each Velvetouch formula, as shown in the photograph above, is only one of many controls by which we assure uniformity of quality. Our laboratories are engaged in never-ending research to improve still further the friction qualities of Velvetouch *all-metal* clutch facings and brake linings . . . so that you may safely specify Velvetouch for rugged, heavy-duty operating conditions in all types of industrial machinery.

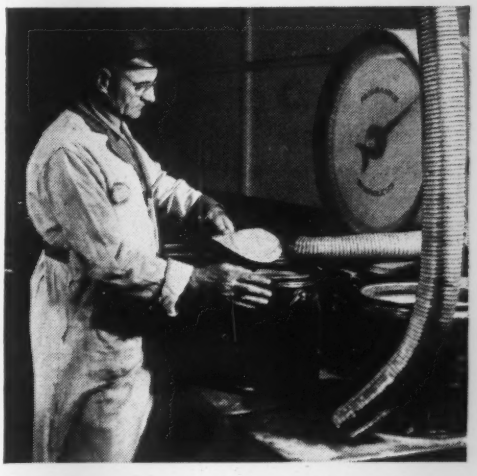
THE S. K. WELLMAN COMPANY

1374 EAST 51st STREET • • CLEVELAND 3, OHIO

Velvetouch is *all metal* —a combination of powdered metals, compressed, sintered and welded to a solid steel backing.

For Brake and Clutch . . . Use Velvetouch

The "INSIDE STORY" of POWDER METALLURGY



CHAPTER 1. Powdered metals—iron, lead, tin, etc.—first are carefully blended in the right proportions for each type of brake and clutch. After thorough mixing, they are ready for the molding and sintering operations.

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MECHANICAL SPRINGS

by A. M. Wahl

. . . eminent authority on springs and well-known for his development of the WAHL CORRECTION FACTOR." He speaks from a wealth of practical experience obtained through his association with the Westinghouse Electric and Manufacturing Company

$6.00* POSTPAID

CONTENTS

General Considerations in Spring Design—Helical Round-Wire Compression and Tension Springs—Open-Coiled Helical Springs with Large Deflection—Static and Fatigue Tests on Helical Springs and Spring Materials—Helical Springs Under Static Loading—Fatigue or Variable Loading of Helical Springs—Practical Selection and Design of Helical Compression Springs—Buckling of Helical Compression Springs—Helical Springs for Maximum Space Efficiency—Tension Springs—Square and Rectangular-Wire Compression Springs—Vibration and Surging of Helical Springs—Initially-Coned Disk (Belleville) Springs—Initially-Flat Disk Springs—Flat and Leaf Springs—Helical Torsion Springs—Spiral Springs—Ring Springs—Volute Springs—Rubber Springs and Mountings—Energy-Storage Capacity of Various Springs—Spring Materials.

BASED on original research and on practical applications, "Mechanical Springs" also includes results of investigations carried out under the direction of the American Society of Mechanical Engineers and the War Engineering Board Spring Committee of the Society of Automotive Engineers.

Fundamental principles and recent developments are presented so that springs can be designed to perform more satisfactorily than if "rule of thumb" methods were employed—saving both time and materials. Being important components of modern machines and devices, springs should be designed with care, especially if fatigue or repeated loading is involved. The information covered puts design on a rational basis. Convenient charts and tables aid quick selection. A glance at the contents will convince you of the comprehensive scope of this book.

TEN DAYS FREE EXAMINATION

for any reason "Mechanical Springs" not exactly what you need, it may be returned within ten days after receipt.

MACHINE DESIGN

Book Department

Penton Building **Cleveland 13, Ohio**

* Orders for delivery in Ohio, 18c additional for state sales tax. Postage will be prepaid if payment accompanies order, otherwise postal charges will be added.

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THE MOTOR for MANY APPLICATIONS

It's the **BALDOR** *Streamcooled*

ALL-PURPOSE MOTOR

Blue lines indicate air travel over ENTIRE EXTERIOR of Baldor Streamcooled Motor.

This post-war engineered BALDOR Motor will simplify your Designing, Purchasing, Production and Inventory. Check its many features:

1. Totally enclosed.
2. Drip-proof; splash-proof; grit-proof; lint-proof.
3. Horizontal, vertical and side wall mounting.
4. Removable base.
5. End plates interchangeable for face mounting.
6. Standard NEMA dimensions.

BALDOR ELECTRIC COMPANY, St. Louis 10, Mo.

District Offices in Principal Cities

PLAN YOUR POST-WAR MOTOR REQUIREMENTS *Now.* Get the Latest BALDOR Bulletins

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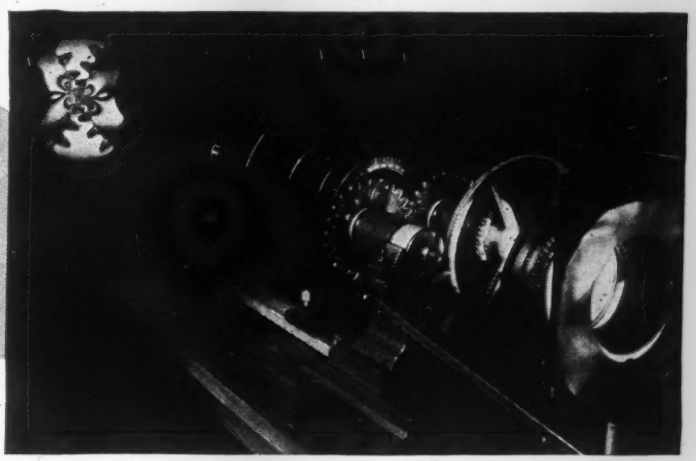
STUDYING STRAINS

as revealed in PLASTIC GEAR MODELS



Of interest to engineers is our new method of observing actual stresses in meshing gear teeth. Photoelastic equipment is used, in these tests, to check visually on mathematical calculations of stresses and strains. A polarized light is passed through transparent gear models and the image on the screen shows in color the lines of stress which develop in the meshing teeth. By substituting a camera for the screen, permanent records of tooth stresses can be made.

Backed by 25 years of experience in making gears, plus careful research work and latest methods of inspection, Fairfield is able to build into gears that special, superior quality essential for satisfactory use.

With an eye to the future, investigate Fairfield's facilities for making fine gears to order. Write for our brochure on gears.

MADE TO ORDER

Hypoid, Helical, Herringbone, Spur, Spiral Bevel, Straight Bevel, Worm and Zerol Gears; also, complete Differentials and various Splined Shafts.

FAIRFIELD MANUFACTURING CO.
311 S. Earl Avenue ● Layfayette, Ind

ARMY E NAVY

FAIRFIELD *for FINE GEARS*

Not Time Yet
for Paper Capers!

Sure, the news is good — terrific, in fact. But don't let that give you the idea that America's paper shortage is over. More paper than ever is needed now to wrap supplies for our armies as they drive toward their goal. There's still a manpower shortage in the pulp industry.

So, you've still got to watch your company's use of paper with the hawk eye of a paper miser.

You've still got to use your ingenuity and that of your staff to find even more ways to *use less paper.*

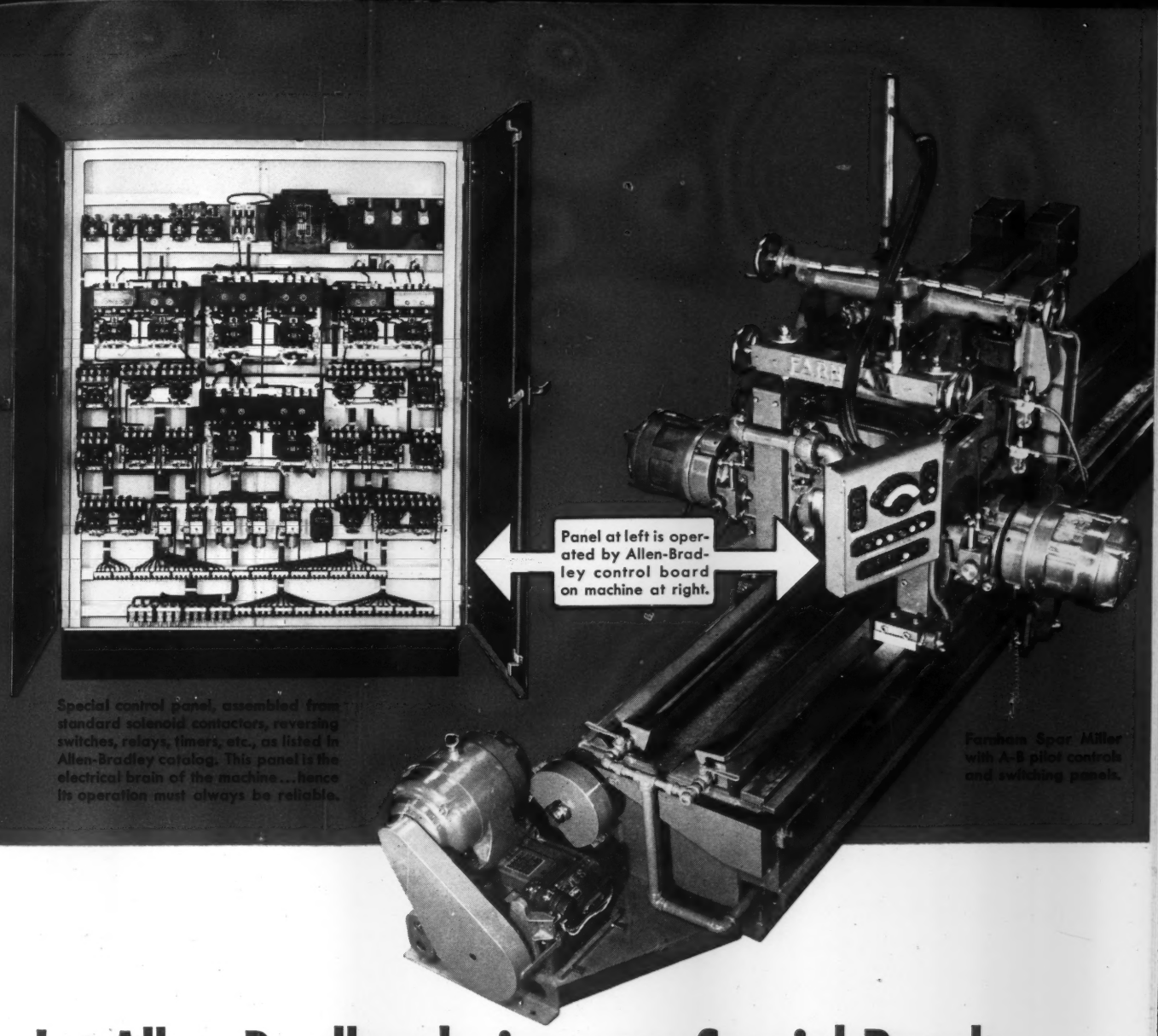
All material made of paper and paperboard still must be cut to the bone. Eliminate whatever you can until complete and final victory ends the paper pinch.

The baling of wastepaper and sending it to the reprocessing plant is still of prime importance.

Remember—
PAPER IS WAR POWER

USE LESS PAPER—SAVE ALL WASTEPAPER

This advertisement contributed by this publication and prepared by the War Advertising Council in cooperation with the War Production Board and the Office of War Information.



Special control panel, assembled from standard solenoid contactors, reversing switches, relays, timers, etc., as listed in Allen-Bradley catalog. This panel is the electrical brain of the machine...hence its operation must always be reliable.

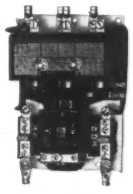
Farnham Spar Miller with A-B pilot controls and switching panels.

Let Allen-Bradley design your Special Panels

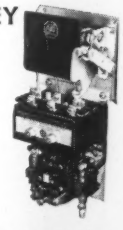
To assure maximum satisfaction to your customers in the performance of your automatic sequence control machines, don't use untried, unknown electrical units on your control panels. Don't experiment . . . don't risk the reputation of your company by using parts of uncertain performance and quality. Let Allen-Bradley engineers design and build special panels of standard units for your motor-driven machines which are field-tested and are backed by Allen-Bradley reputation for quality control. Make Allen-Bradley your control engineering department . . . and avoid complaints.

TYPICAL ALLEN-BRADLEY STANDARD UNITS FOR ASSEMBLING SPECIAL PANELS

RELAYS

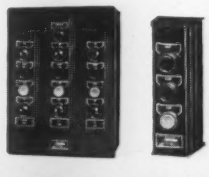


STARTERS

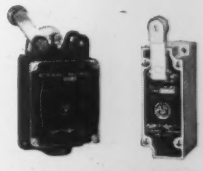


COMBINATION

REVERSING



CONTROL STATIONS



LIMIT SWITCHES

ALLEN-BRADLEY

SPECIAL PANELS FOR MACHINE TOOLS

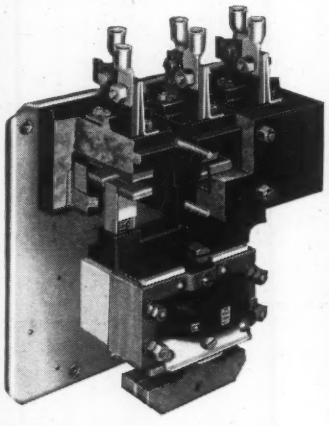
QUALITY

Big or Small

all Bulletin 709 Starters are Solenoid-Operated

The five Allen-Bradley Bulletin 709 solenoid starters, shown below, have been making notable control history for the past ten years.

The first starter, introduced in 1934, was Size 1 for 5 hp., 220 v., 7½ hp., 440-550-600 v. It smashed all performance records of clapper switch starters and, for the first time, made possible precision motor control for machine tools. It set the pattern for modern motor control design and performance.



Sectional view of 150 ampere Bulletin 709 starter showing solenoid plunger, contacts, and terminals, all mounted on steel plate.

Since then, four more sizes have followed, extending the Bulletin 709 line up to 50 hp., 220 v., and 100 hp., 440-550-600 v. In all sizes, the highly successful Allen-Bradley solenoid principle is used. Only one moving part . . . no pins . . . no pivots, hinges, or bearings . . . no contact maintenance . . . no variation in switching performance. No starter is so simple . . . nor so trouble-free.

Unfailing dependability and accuracy in opening and closing of circuits are essentials in machine tool control . . . and Bulletin 709 starters meet these requirements under all service conditions. It will pay you to standardize on A-B controls.

Contacts closed

Only ONE Moving Part

Contacts opened

Allen-Bradley Company
1316 S. Second St., Milwaukee 4, Wis.

ALLEN-BRADLEY

SOLENOID MOTOR CONTROL

QUALITY

Here's How Grumman Engineers Solved a Landing Gear Problem with

.....ARENS REMOTE CONTROLS

Grumman engineering ingenuity makes effective use of remote Controls on the new Hellcat to prevent landing gear retraction when plane is on the ground. Pilot's control lever cannot be moved to the retract position until the compression load is removed from the oleo strut which occurs in flight only.

An Arens flexible remote control is performing this vital function which has eliminated the possibility of pilot error and is safeguarding the Hellcat from accidental mishaps. Arens Controls, Inc. has specialized in the manufacture of quality remote controls for over 20 years and invites your inquiry.

Write for catalog and enclose details on your problem. One of our engineers will submit a control design engineered to your individual application.

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CONTROLS, INC.
2257 South Halsted Street, Chicago 8, Illinois

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• Subject to prior engagement, this company offers certain facilities of one of the finest equipped machine shops in the Mid-West, for contract production. Some of our government contracts have now been completed, and we are in position to share the output of our equipment of new, modern turret lathes, 3¾" automatics, millers, grinders, boring mills, etc., with other manufacturers now engaged in military or essential civilian production.

In addition, our engineering and designing division can offer limited services in developing new machines or parts, and in modernizing pre-war models. *Write for literature and explain your problem.*

MERZ *Engineering Company*
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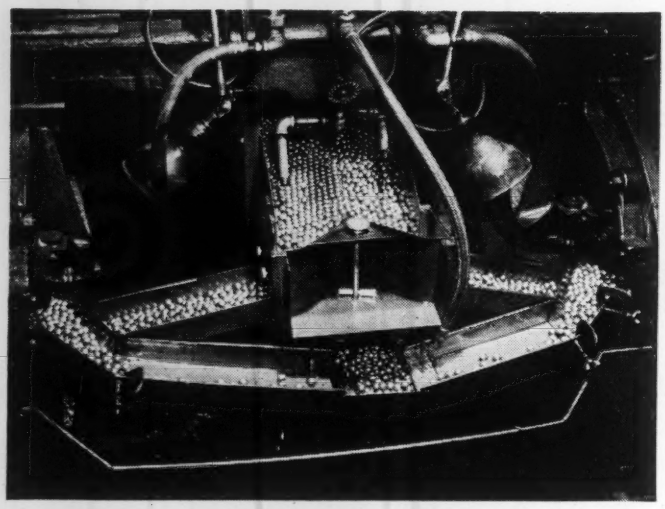

The front section of a modern grinding machine where the balls are ground to the required sphericity and size tolerance.

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Never before in the annals of military history has an offensive moved with such clock-like precision and speed as that of General Eisenhower's invasion of France.

From the initial Normandy landing, thence to Cherbourg, Brest, Saint Nazaire, Belgium, Holland and right onto German soil, men, machines and materials moved into position on split second schedules.

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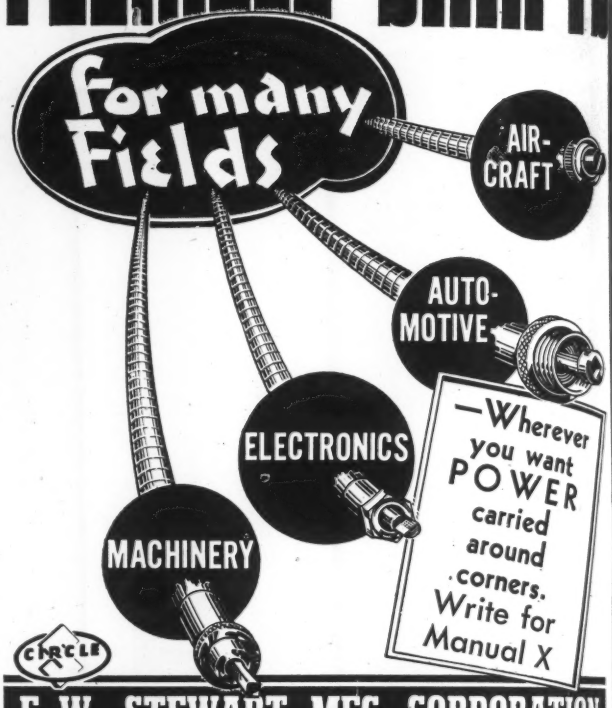

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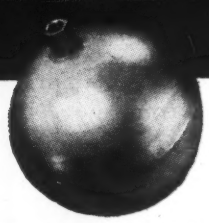

The strength and corrosion resistance of stainless steel makes floats of this material particularly adapted to many services where ordinary floats would be short-lived. Stainless steel floats may be safely used at operating temperatures up to 800 deg. F. For more severe service, at temperatures up to 1600 deg. F., floats of stabilized 18-8 stainless steel, with Chicago Float Works stabilized weld, make the most of the exceptional corrosion resistance of this material. Spherical (ball) shape only, with standard connection fitting, or without connection. Standard sizes, 3 to 10 inch diameter.

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- FABRIC PRODUCTS, through "Engineering in Fabrics", are fully utilizing the improved methods of treating and coating standard fabrics and gaining the advantages of the many new war-developed synthetic fibers.

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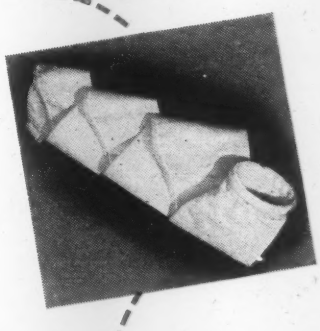

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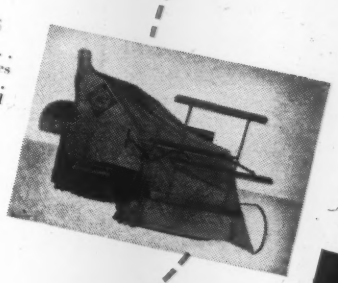

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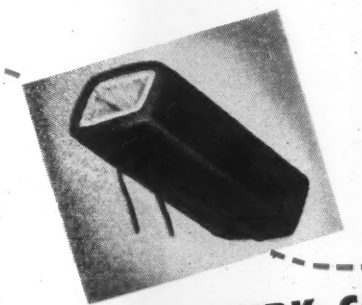

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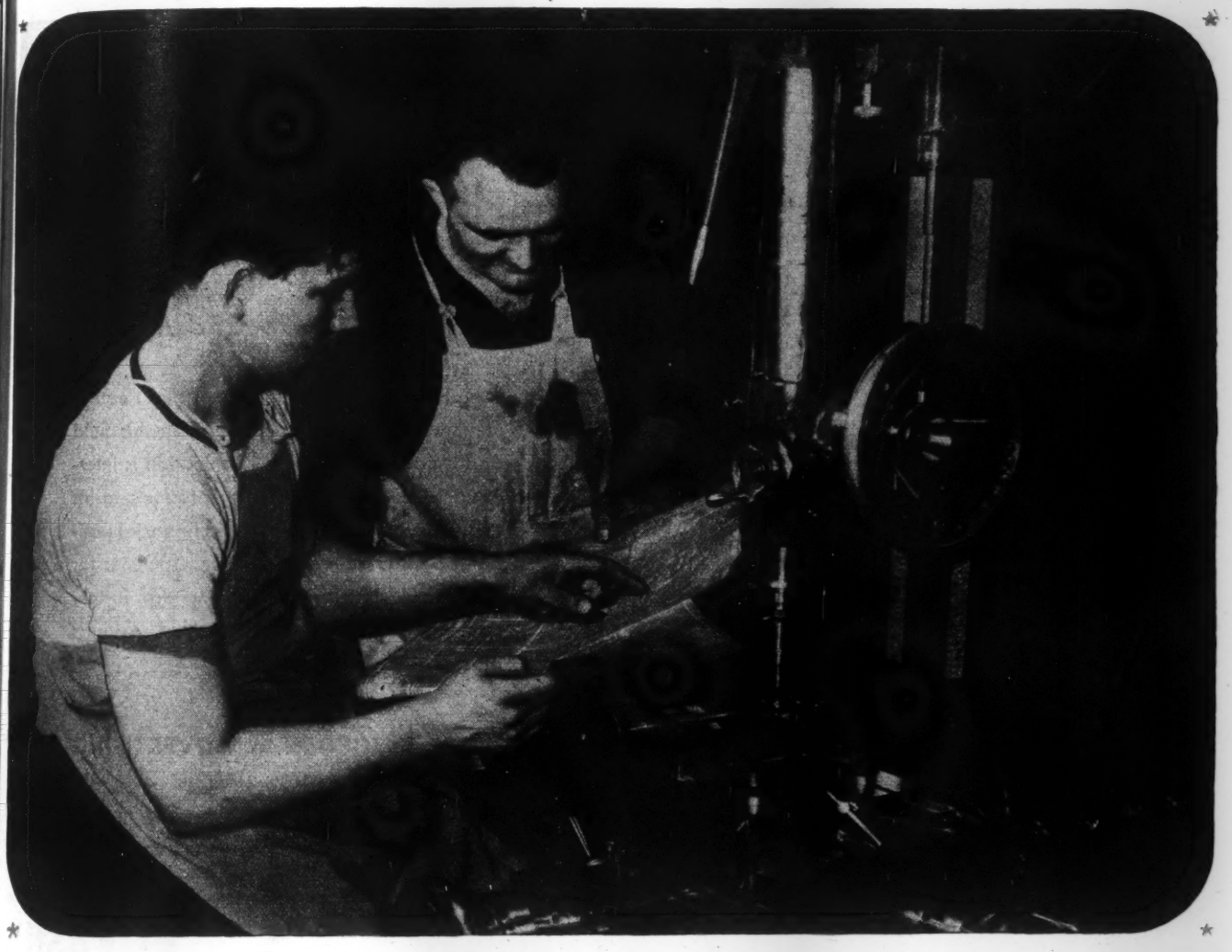

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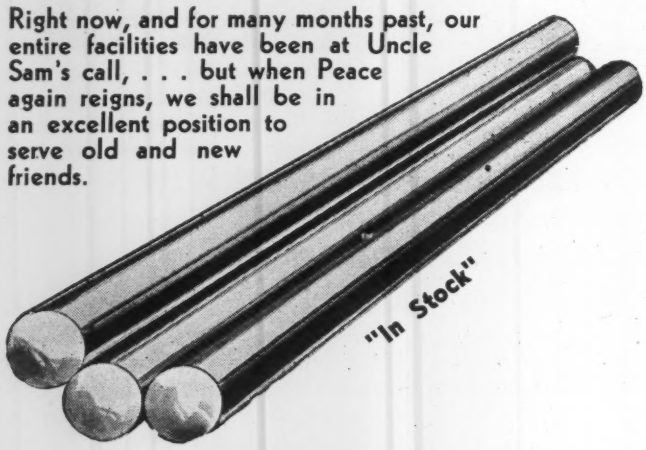

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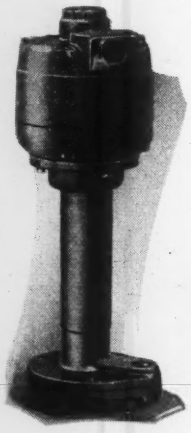
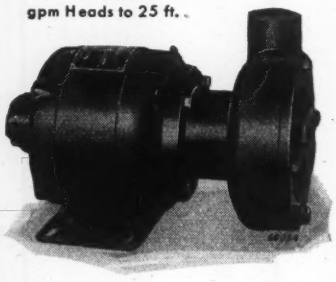
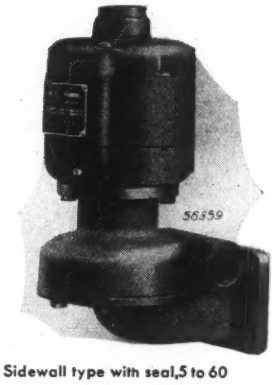
Sidewall type without seal, 5 to 50 gpm Heads to 19 ft.



Immersion type, 5 to 150 gpm Heads to 125 ft.

Horizontal type, 5 to 60 gpm Heads to 25 ft.





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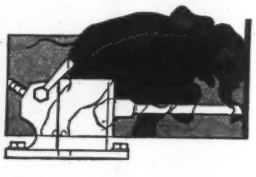

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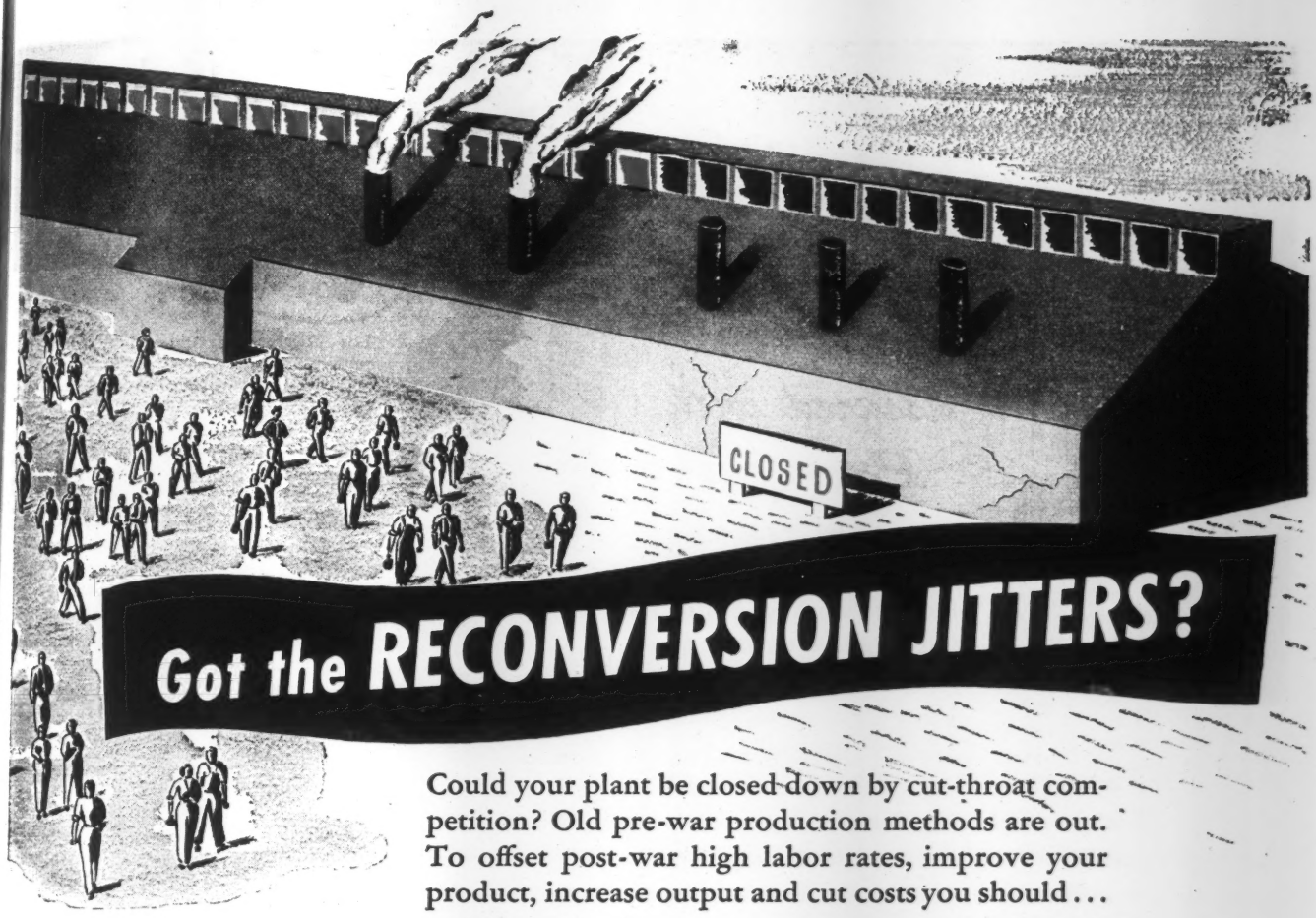

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Could your plant be closed down by cut-throat competition? Old pre-war production methods are out. To offset post-war high labor rates, improve your product, increase output and cut costs you should...

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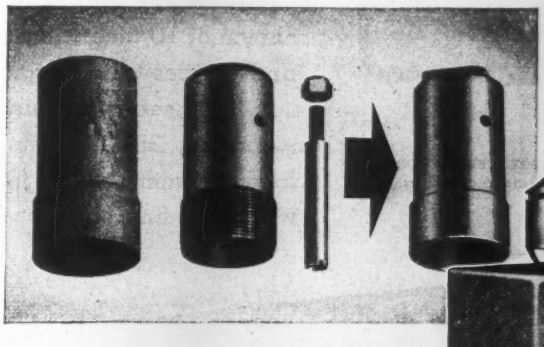

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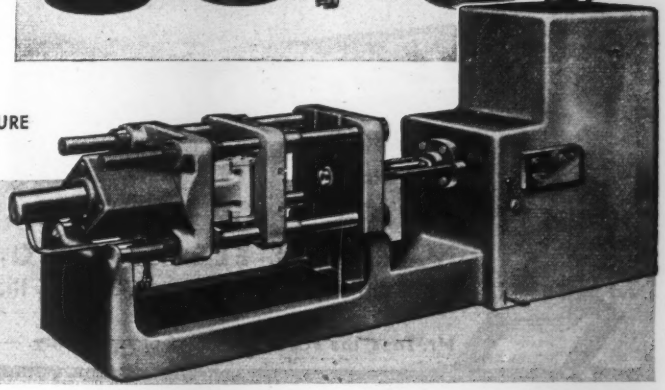

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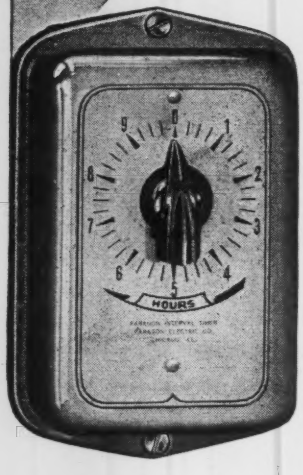
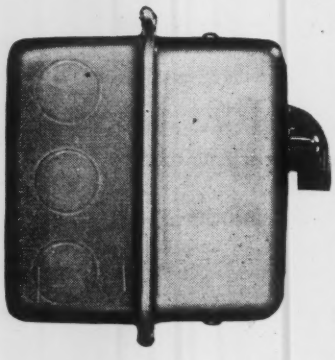
PRESET TIMERS



2509 for surface mounting.



2509 for gang switch box or handy box mounting.

Paragon improved manually preset timers can be preset to perform a great variety of operations . . . to allow a given operation to continue for almost any pre-determined time limit . . . to close or open a circuit at the end of the preset time. Synchronous motor operated. Assures absolute accuracy of the timing cycle. Not affected by vibration or changes in ambient temperature. Supplied as standard with single pole, double throw switches and choice of 10 time ranges and 3 types of mounting . . . 2400 series for flush mounting, 2500 for surface mounting, 2900 for wall mounting.

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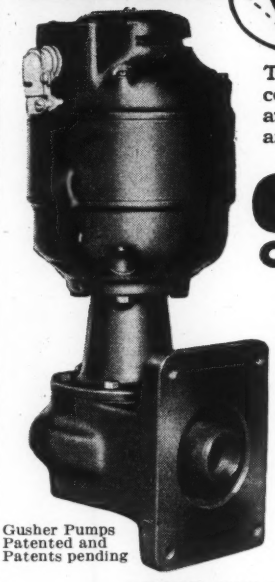

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MODEL 11020-A

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Let's look at the record...

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- ★ HELICAL
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- ★ SPECIAL

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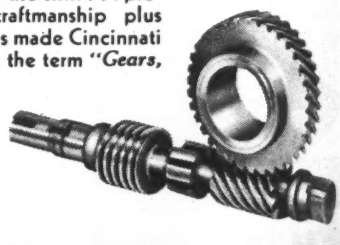
Dependability can't be written in. It must be built in. In gears it's the skill . . . precision . . . control . . . craftmanship plus the "know how" that has made Cincinnati Gears synonymous with the term *"Gears, Good Gears Only!"*



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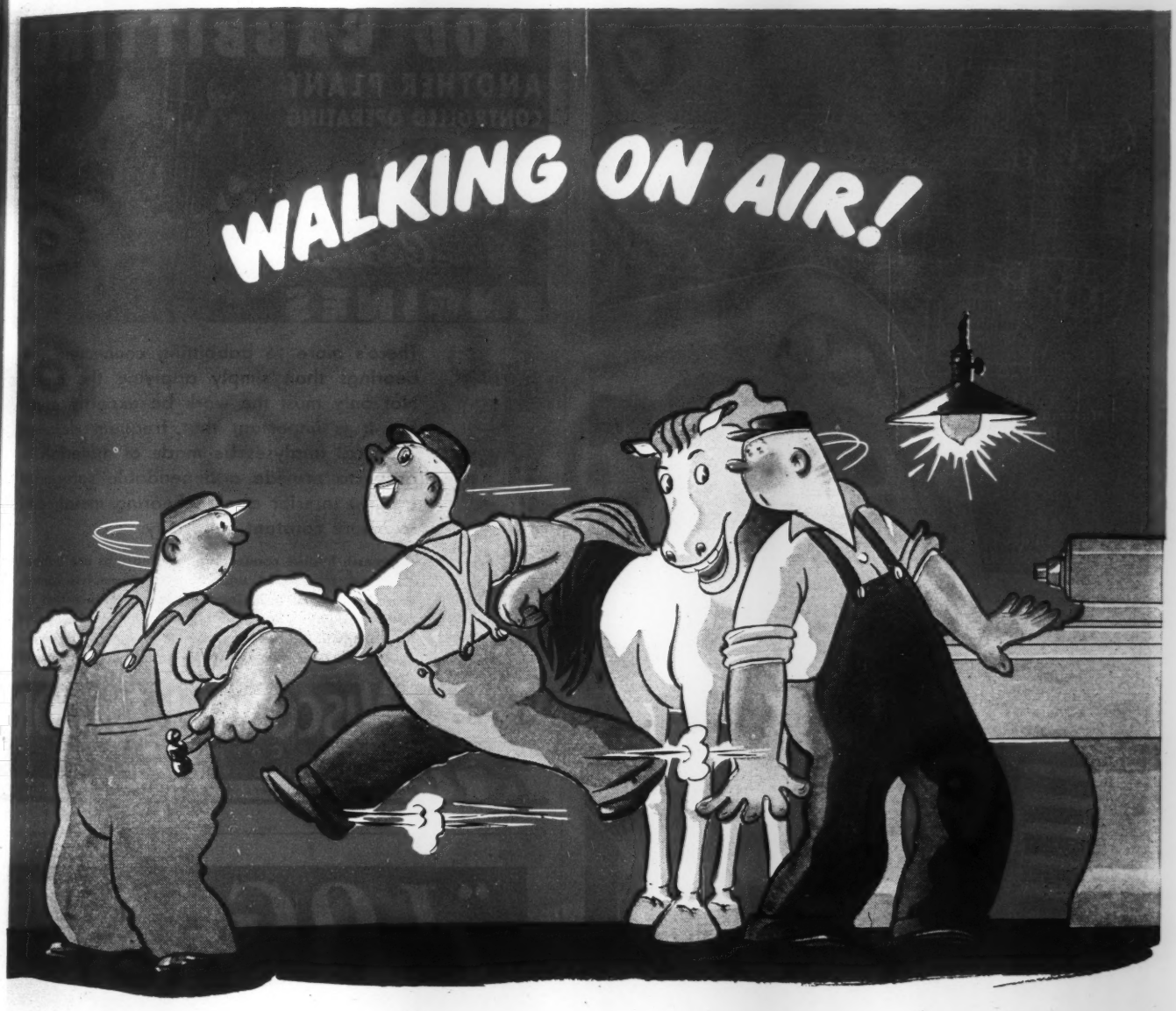

The Howell Protected Type Motor, shown, gives complete protection against dripping liquids, metal chips and other falling particles. Completely streamlined—utilizing non-breakable steel frame—malleable or steel base—cast iron end plates and cast iron, weatherproof terminal box are standard construction features. Special horizontal and vertical mountings are available.

Available in sizes 5 H.P. and smaller.

The tens of thousands of owners who already have Howell Motors are "walking on air." Producers do like quality.

But, we all know the entire electric motor industry is confronted with a serious situation today. Demands for motors are up. Manpower is short. Materials are scarce.

While we are swamped with orders for Howell Motors, we have flatly refused to skimp on quality in order to speed production. However, we fully recognize our obligation to put forth the maximum effort in serving our customers NOW! This, we are doing.

Buy Horsepower by

HOWELL ELECTRIC MOTORS COMPANY

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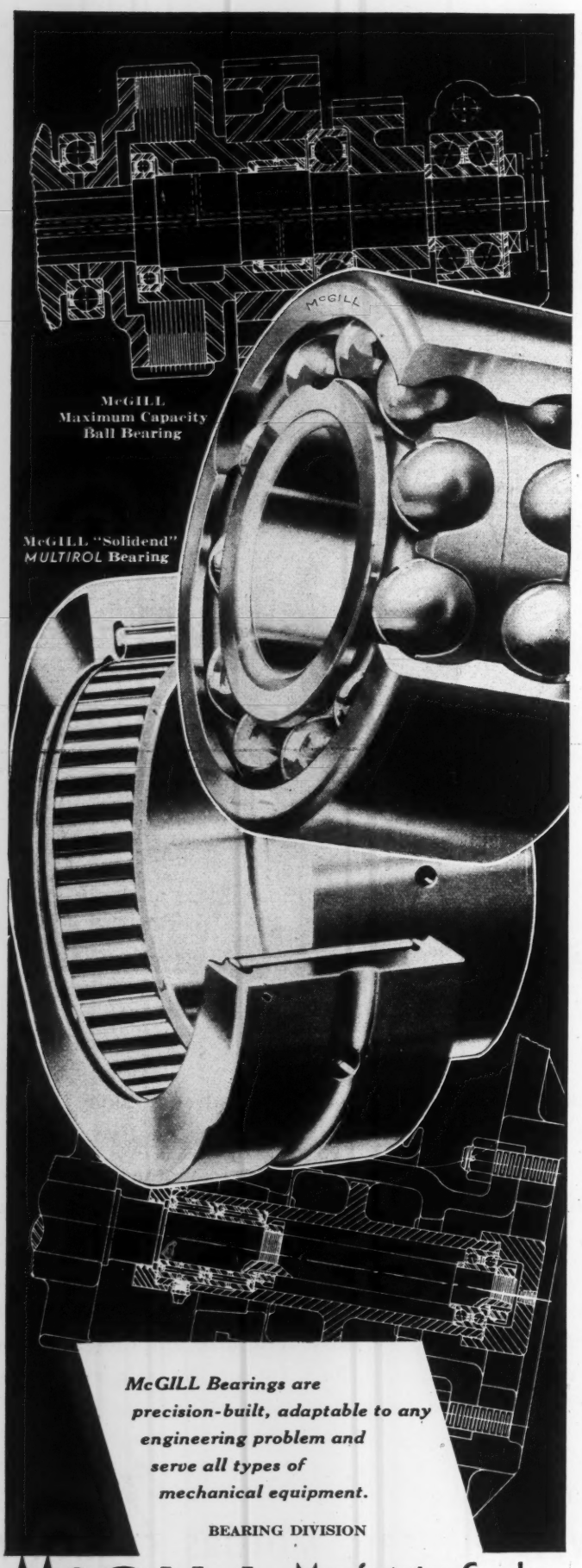

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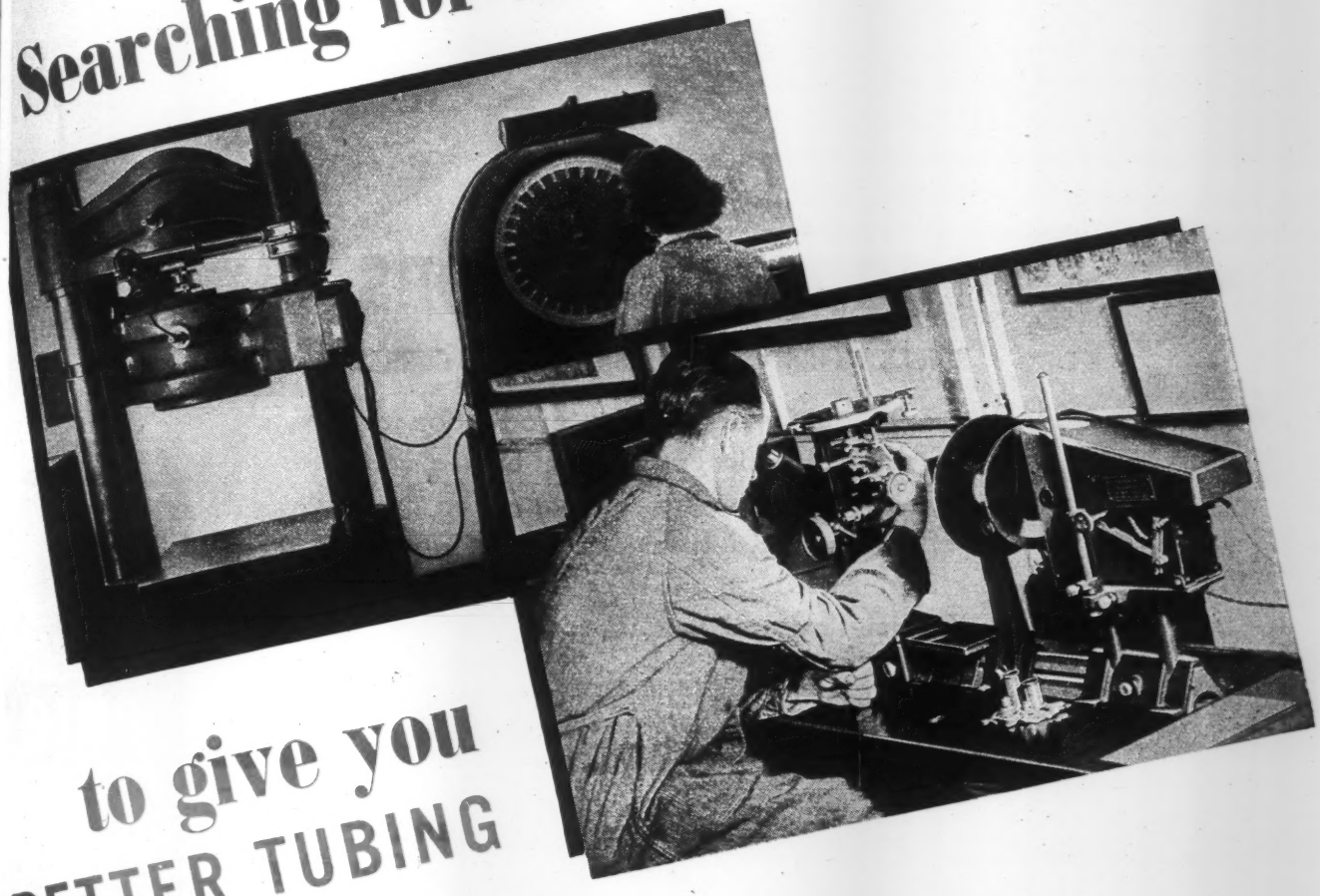

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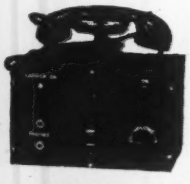

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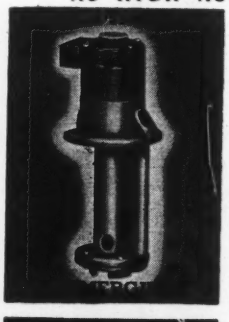

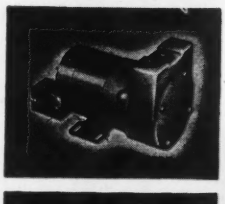

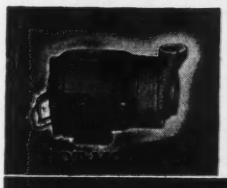

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⅛ H.P. Motor Replaces ¼ H.P. through superior pump design. All motors have 20% surplus power.

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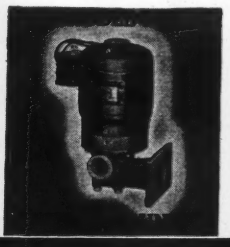
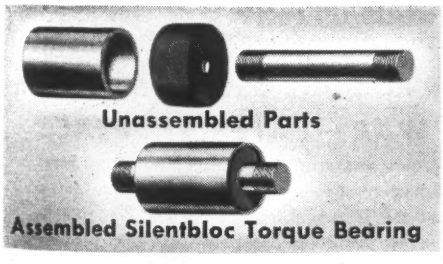


BRADY - PENROD, INC.

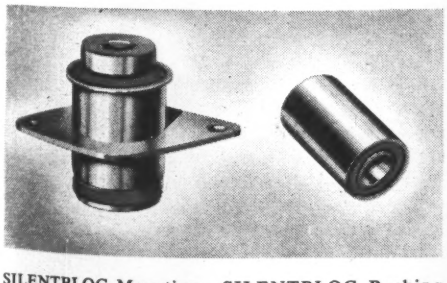
2510 S. MADISON ST. MUNCIE, INDIANA

Silentbloc in Your New Blueprints Means a Better Product...Lower Costs

Silentbloc Rubber Mounting above is used to damp or isolate vibration and cushion shock loads in motors and other moving equipment.



PATENTED CONSTRUCTION gives engineered performance. Silentbloc consists of outer metal sleeve into which rubber ring is forced under high pressure and inner shaft, "shot" through rubber. Radial compressive force of elongated rubber forms indestructible rubber-to-metal union.



SILENTBLOC Mounting gives engineered control of vibration in motors and moving equipment, cushions shock loads, absorbs noise.

SILENTBLOC Bushing corrects for misalignment of hinges, shafts, bearings. Improves operation, cuts machining and fitting costs.

BEFORE you approve any blueprint, check the improvements you might make with General Silentbloc mountings, bearings and bushings.

If you have a problem of vibration, shock load or noise, a Silentbloc mounting can be engineered for your specific needs.

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You can improve performance and cut production costs with Silentbloc rubber bushings that correct for misalignment of shaft supports or bearings.

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It Will Pay You to Know More About Silentbloc

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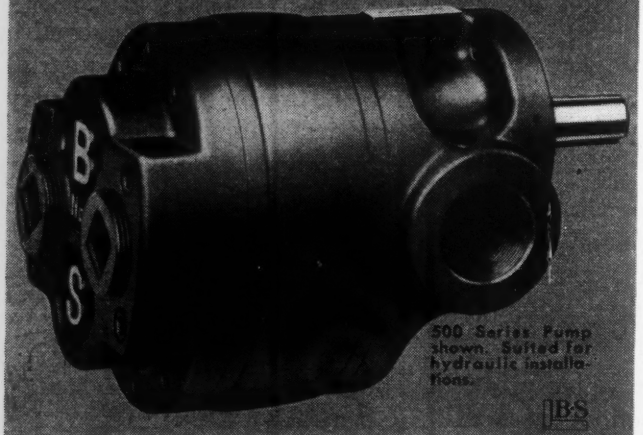

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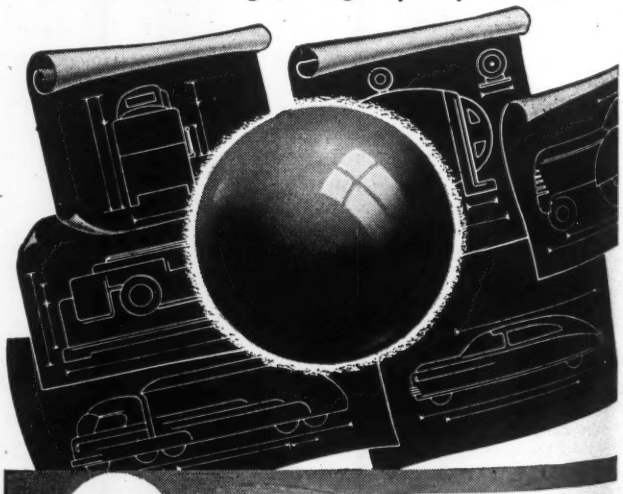

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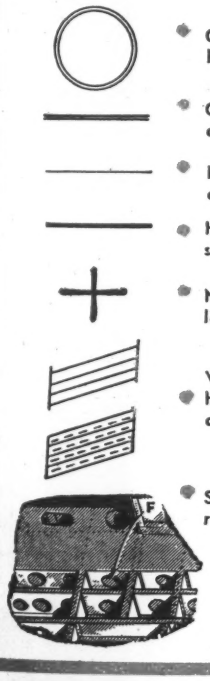

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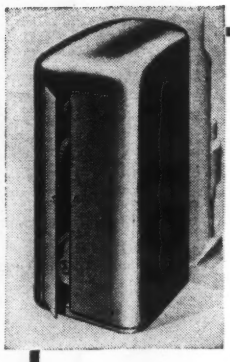

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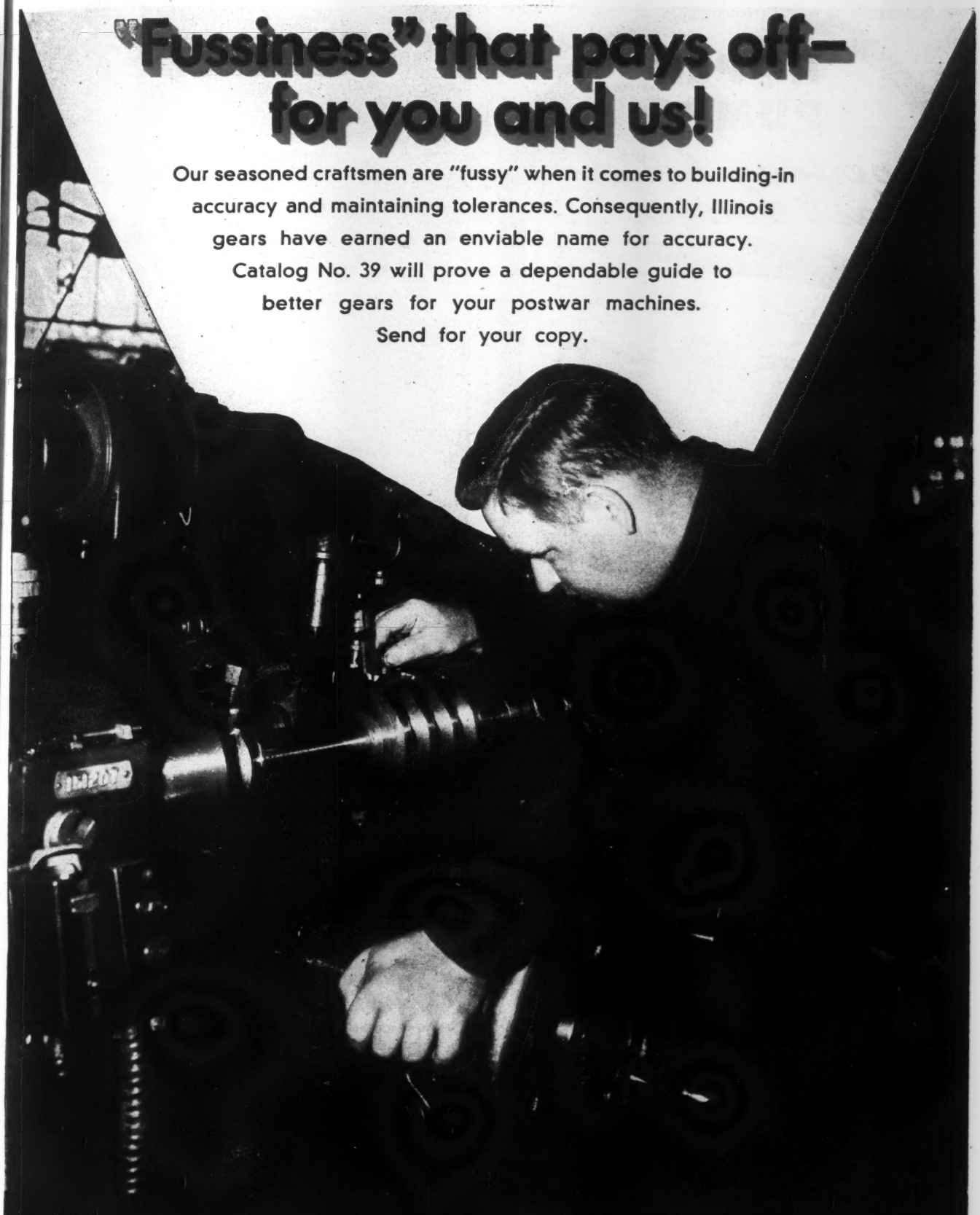

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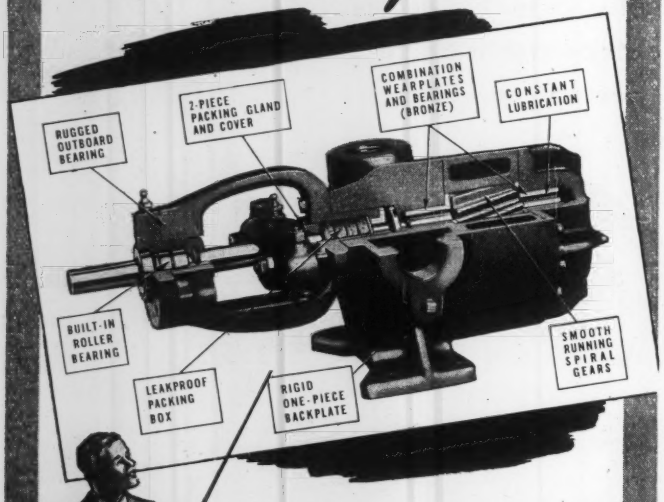
ROPER PUMPS

perform better last longer ...



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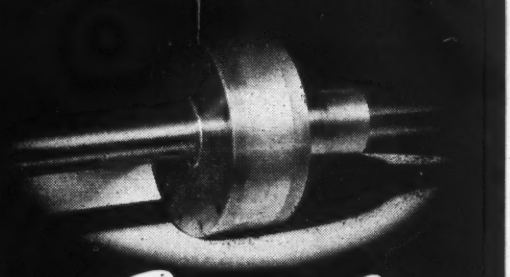

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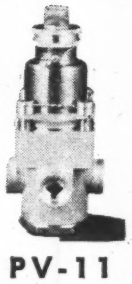

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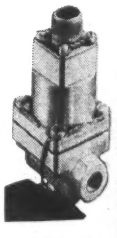
General Controls' PV Series portable electro-magnetic valves *operate in any position regardless of vibration, acceleration, or change of motion.



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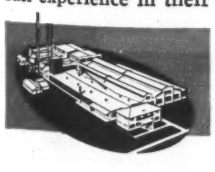

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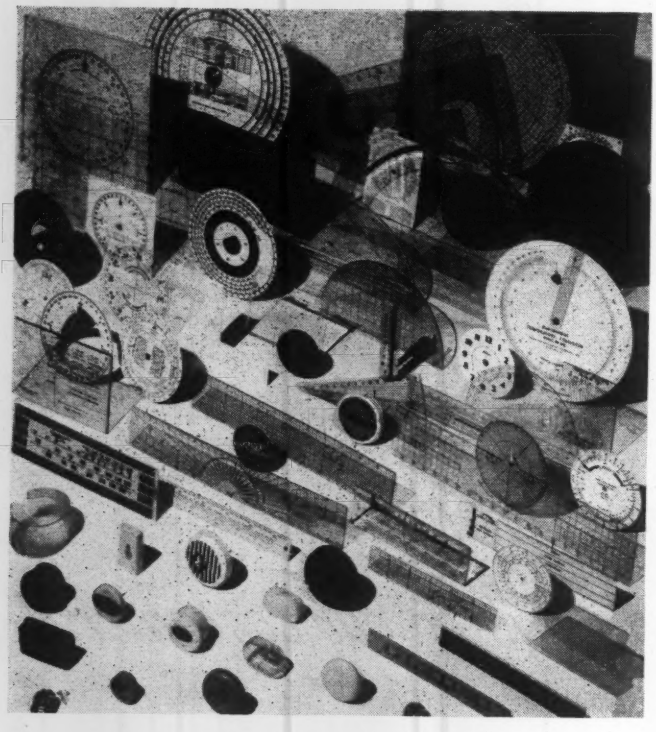

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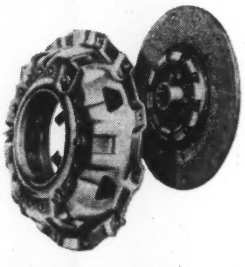

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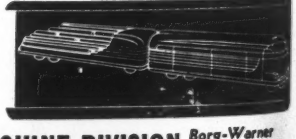

They provide for instant pick-up, convenient power transmission control and smooth gear shifting—with disengagement maintained by light foot-pedal or hand-lever pressure.

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Full Rated Capacity —but *Half the Size!*

With the new Cleveland Speedaire Worm Gear Unit it is possible to obtain an operating capacity equal to that of a standard worm gear unit having approximately double the frame size.

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FOR YOUR SLOW SPEED MACHINES

There Are 11 Sizes of this particular style of worm gear speed reducer, which can be furnished with JANETTE motors of from **1/8 to 7 1/2 H.P.**, and output speeds of **.08 to 447 r.p.m.**

As this style reducer can be furnished with foot or flange bases and assembled in **12 different mounting positions**, it can be easily installed without special adapters on almost any slow speed machine.

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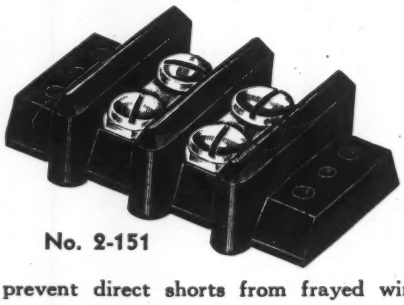

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6 SIZES

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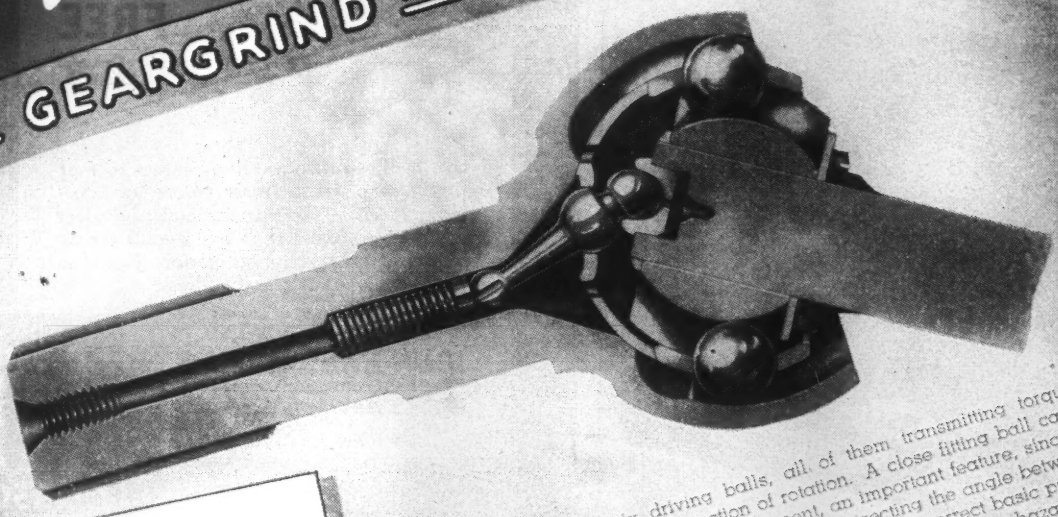

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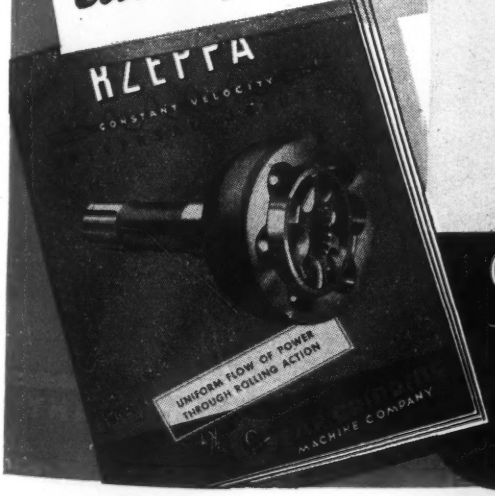

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Screw Machine Products

POST WAR DATA BOOK

This new publication brings together in readily accessible form much information helpful to designers of screw machine products, new product development departments, production engineers, men responsible for costs and efficiency.

Contents

with page numbers

Definition of Screw Machine Products, 3; Advantages of Screw Machine Products, 3; Selection of Material, 3; Selection of Stock Sizes, 4; Selection of Screw Thread Sizes, 5; Comments on Threading to a Shoulder, 6; Thread Fits, 6; Studs, 7; Threaded Rods, 7; Drawings, 7, 8; Marking Symbols for Indicating Thread Sizes, 8; Multiple Threads, 8; How to Purchase Screw Machine Products, 8; Suggestions on Drawings, 9; Dimensions of Finished Hexagon Screw Heads, 9; Distance Across Corners for Square, Hexagon and Octagon, 9; American National Form of Thread and Gages, 10; List of Stockable Die Head Chasers, 10; Tap Drill Sizes, 11; Basic Data for Coarse Thread Series, 12; Data for Coarse Thread Series for Class 2 Fit for Screws and Tapped Holes, 12; Basic Data for Fine Thread Series, 13; Data for Fine Thread Series for Class 2 Fit for Screws and Tapped Holes, 13; 8, 12 and 16 Pitch Thread Series, 14; National Extra Fine Thread Series, 14; 27 Pitch System, 14; Tolerances for Class 2 and Class 3 Fits, 14; Pipe Thread Data, 15, 16; Acme Threads and Stub Acme Threads, 16; Stub 60° Thread, 17; Spark Plug Sizes, 17; Basic Thread Data for Various Pitches of Threads, 17; Decimal Inch Equivalent of Millimeters, 17; Table of Metric Pitches showing Equivalent in Inches and T.P.I., 17; Table of Standard Drill Sizes with Decimal Equivalents, 18; Suggested Surface Feet for Different Types of Steels, 19; Weights Per Lineal Foot for Different Sizes of Steel, Brass and Aluminum, 19; Cutting Speed Chart Showing R.P.M. for Different Feet Per Minute, 19; Decimal Chart, 19; A.I.S.I. Standard Steel Chemical Composition Table, 20; Non-Ferrous Metal Table giving Nominal Composition, Tensile Strength and Machinability, 21; H & G Die Heads, 22, 23

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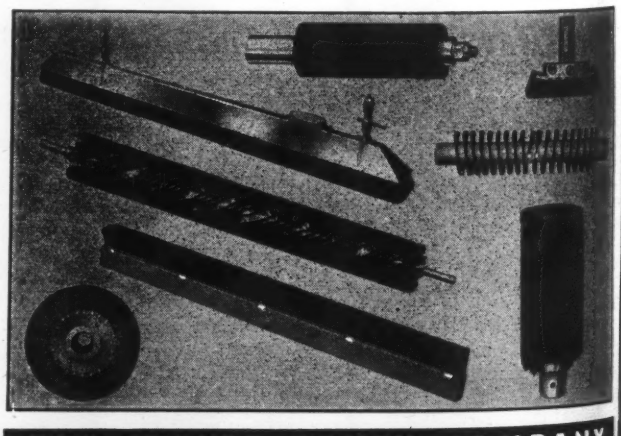

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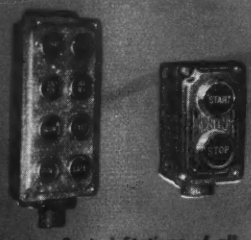

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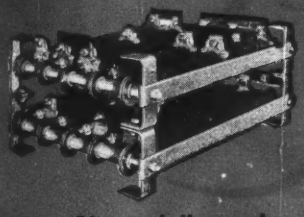

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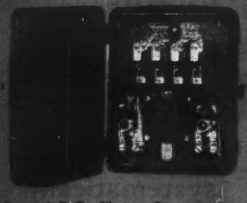

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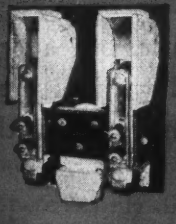

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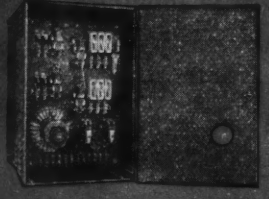

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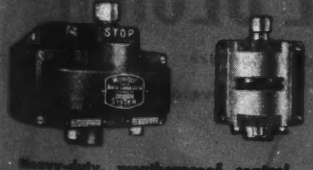

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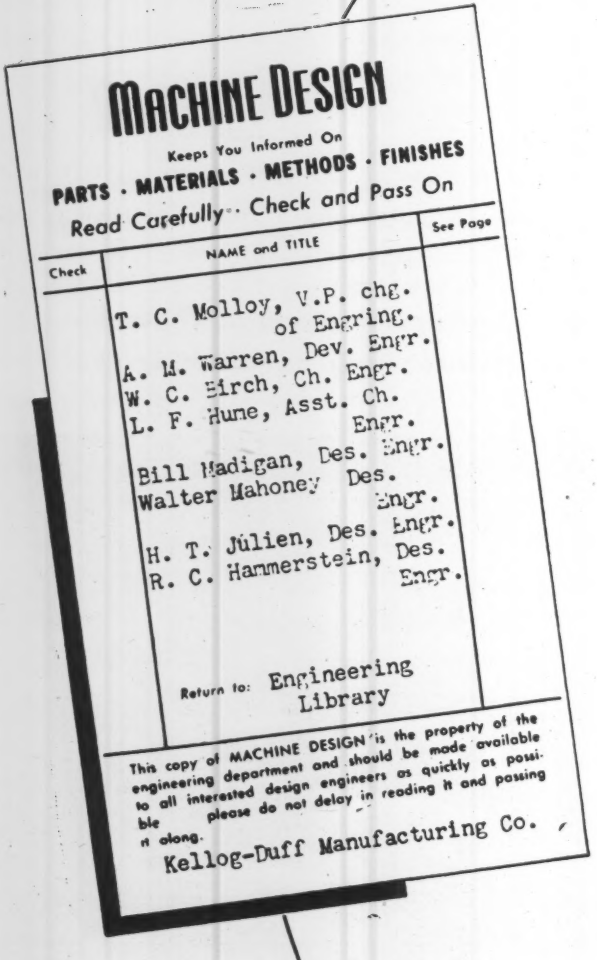

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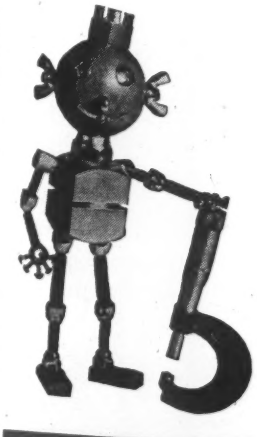

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HELPFUL LITERATURE

for Design Executives

1. Plastic Parts

Kurz-Kasch, Inc.—4-page illustrated bulletin "The Kurz-Kasch Round Table" shows how molding design and mold making experience of company are coordinated in producing precision molded plastic parts in all sizes and shapes. Typical stock parts which include knobs, push buttons, dials, control balls and cosmetic containers are shown. Plant facilities for custom molding are described.

2. Reproduction Paper

Craftint Mfg. Co.—10-page illustrated reference folder No. 5 shows use of "Doubletone" reproductions for catalog drawings which are used in operator's service manual of large turret lathe company. Shadings of drawings for perspective and third dimensional effect are easily incorporated because of automatic shading features of this paper.

3. Relays and Solenoids

Guardian Electric Mfg. Co.—4-page illustrated bulletin "Relays by Guardian" gives details and operating characteristics of eight standard relays and eight solenoids. Charts show standard voltages, maximum contact capacities, coil resistance and operating current. Data on solenoids includes resistance and operating current as well as stroke and lifting capacities.

4. Industrial Paper

Central Paper Co.—16-page illustrated booklet entitled "Industrial Papers—The New Production Answer" explains use of paper in industry as flexible, versatile material. How physical and chemical properties of paper can be controlled to meet industrial requirements is shown and typical applications are suggested by quick index of 68 different papers giving their characteristics and uses.

5. Locking Pins

Driv-Lok Pin Co.—8-page illustrated booklet on "Driv-Lok" pins explains advantages of these units which are designed to replace taper pins, keys, straight pins, cotter pins, set screws and rivets. Typical applications in assembly of machine elements are shown. Specifications and prices for various types are included.

6. Casters

Rapids-Standard Co. — 40-page illustrated catalog No. 65-2C shows construction features and available types of industrial casters for use on all types of mobile and materials handling equipment. Stationary and swivel models are available in wide range of constructions for practically any floor condition. Both roller and "Oilite" bronze bearings can be furnished.

7. Molybdenum Alloys

Molybdenum Corp.—20-page illustrated bulletin on "M.C.A. Products" briefly describes molybdenum, tungsten and boron, as well as ferro-alloys, metal powders and chemicals produced by company. Available forms, uses and other technical data are given on all compositions.

8. Automatic Couplings

A. Y. Dodge Co.—2-page illustrated folder No. 101 describes "A.Y.D." automatic couplings which release torque overloads automatically, re-engage after power is shut off, run freely with no drag in released state, are totally enclosed, and offer flexible resilient coupling between driving and driven units.

9. Plastics Molding

Midland Die & Engraving Co.—16-page booklet "Shaping Tomorrow—Today" describes personnel, engineering experience and production facilities of this company in producing dies or molding plastics to precision specifications. Services offered by company are covered in detail.

10. Self-Tapping Screws

Parker-Kalon Corp.—18-page, file size, tab-indexed "Users' Guide" contains engineering and production data on application of self-tapping screws. Included is selector chart which indicates which of nine types of screws should be used in different materials. Recommended hole sizes, stock sizes and data on each type of self-tapping screws are presented. Application information covers use of screws in sheet metal, steel, castings, plastics, plywood, asbestos and other compositions.

11. Non-Metallic Materials

Continental-Diamond Fibre Co.—12-page illustrated catalog No. GF 23 gives properties of "Diamond" vulcanized fibre, "Dilecto" laminated phenolic plastic, "Dilectene" synthetic resin, "Celoron" molded phenolic impregnated material, "Micabond" plate or sheet type insulating material and "Vulcoid" fibre-like insulating material which is available in sheets, rods, and fabricated parts. Grades and sizes of all of these non-metallic basic materials are described.

12. Fastening Devices

Manufacturers Screw Products—8-page illustrated folder is current stock list of "aviation fastener items." Stock number, available quantity and sizes are given for AN-AC machine screws and fasteners for aircraft applications. Included is stock list of commercial and special fasteners which are available.

13. Reproduction Method

Ozalid Products Div., General Aniline and Film Corp.—4-page illustrated bulletin "Simplified Printmaking With Ozalid" shows ease with which this method can produce reproductions of printed or drawn copy. Exposure and dry development are only steps required. Specifications are given for printing and dry developing machines.

14. Ball Bearings

Marlin-Rockwell Corp.—160-page design portfolio on "Ball Bearing Practices" is comprised of 27 bulletins dealing with all design and application phases related to ball bearings. Handling, shafts, housings, seals, lubrication, mountings, fits, snaprings, replacement bearings and lock nuts are some of subjects covered.

15. Flexible Couplings

Philadelphia Gear Works—16-page illustrated bulletin No. 150 deals with complete line of flexible couplings which include steel flanged, "Philflex Oldham," "Thermoid," "CW," "Poole," "Francke" and "Ajax" types. Complete dimensions and ratings are tabulated for each unit. Brief descriptions and application data are given.

16. Self-Locking Nuts

Palnut Co.—4-page illustrated bulletin No. 550 describes type 6NA0 "Palnut" which is designed for use either as adjustment nut or as self-locking nut for light weight assemblies. In addition to explaining advantages of design, sizes, typical applications, load capacities and dimensions are given. Nuts are made in 6-32 to $\frac{1}{4}$-18 thread sizes and afford vibration resistant fastening.

17. Protective Finishes

Amercoat Div., American Pipe & Construction Co.—16-page illustrated catalog on "Amercoat" plastic coatings describes comprehensive list of organic and inorganic materials, foods, beverages, equipment and structures which can be protected against corrosion or contamination. Specifications are given for complete line of finishes.

18. Small Turbines

General Electric Co.—20-page illustrated bulletin No. GEA-1145D gives design and application information on type D mechanical-drive turbines. These units which are available in capacities ranging from 5 to 200 horsepower are adaptable for producing economical power as byproduct of process steam. They are designed to drive general purpose equipment in industrial plants as well as for auxiliaries in power houses. Typical installations are shown.

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19. Seamless Tubing

Tube Reducing Corp.—16-page illustrated bulletin on "Rockrite Seamless Tubing" contains pertinent information on the design and production of metal parts of generally cylindrical form which can be made from tube stock. These parts include ferrules, bushings, sleeves, spacers, cylinders, bar and roller bearing races and hollow shafting. Process employed in producing precision, close tolerance, cold reduced seamless tubing is described. Typical applications are shown briefly.

20. Synchronous Motors

Warren Telechron Co.—20-page illustrated bulletin No. 3a-16 contains design and engineering data on synchronous motors, instrument movements, gear trains or speed changers and industrial clock equipment. Data are included to aid in selection of standard "Telechron" motors for specific applications. Available motors and timing units are described in detail.

21. Small Centrifugal Pumps

Eastern Engineering Co.—8-page illustrated catalog No. P-106 gives detailed information to aid in selection and application of small single and multi-stage centrifugal pumps and small gear pumps. Performance characteristics, specifications and complete description are given on various types of pumps.

22. Molded Plastics

Erie Resistor Corp.—12-page illustrated bulletin on "Erie Custom Injection Molded Plastics" shows design, engineering and production facilities of this company for manufacturing injection molded plastic parts. Typical moldings, available materials, extruded tubing and finishing operations are discussed.

23. Drop Forging

Drop Forging Association—40-page illustrated engineering manual entitled "Metal Quality" explains how hot working improves quality of metal. It deals with characteristics of forging material and explains properties which can be obtained by forging methods. Typical structures and parts are shown.

24. Variable Speed Drive

Lombard Governor Corp.—4-page illustrated bulletin on the "New Lombard" variable speed drive explains advantages of this compact unit which provides practically unlimited speed ratios for applications requiring from 1 to 100 horsepower. Unit consists of simple gearing transmitting power and light V-belt which varies speed ratio. Drive is applicable for manual, lever or remote control requirements.

25. Aluminum

Reynolds Metal Co., Aluminum Div.—16-page illustrated catalog No. 100 is entitled "Reynolds Aluminum—Its Important Role in Tomorrow's Products." Advantages, properties, applications, principal forms, fabricating finishing and company's fabricating service are some of the subjects covered in detail. Typical parts and assemblies produced are shown.

26. Universal Joints

Gray & Prior Machine Co.—4-page illustrated bulletin on "Vulcan" universal joints covers applications and design features of these joints which operate at up to 45 degrees and swing 90 degrees in stationary position. Sizes range from $\frac{7}{16}$ to 2-inch diameter.

27. Resin Baking Coatings

Bakelite Corp.—24-page illustrated catalog of "Bakelite Resin Baking Coatings" contains information on properties and characteristics of phenolic resin baking coatings. Technical data are given on types of surfaces which can be coated with these finishes; methods of application; baking processes and equipment; properties of finishes, and list of tested and approved applications.

28. Cowl Fasteners

Camloc Fastener Corp.—8-page illustrated catalog No. 44A is descriptive of No. 4002 series "Camloc" spring loaded stud cowl fasteners. These three-part assemblies provide easily installed, operated and maintained fastening for panels or cowl sections which must be removed for inspection or maintenance. Devices are vibrationproof and lock with quarter turn of screw driver. Specifications are given for various type of units all of which comply with AN specifications.

29. Time Meter

National Instrument Co.—4-page illustrated folder No. 844 describes "Timeter" quick re-set type electrically operated timing instrument which automatically registers total operating hours of any electrical device or motor driven machine. Instrument operates on 110-volt, 60-cycle alternating current and resistor can be supplied for 220-volt alternating current applications. Time is registered by tenths of hours up to 999.9 hours.

30. Variable Speed Drive

Electron Equipment Corp.—4-page illustrated bulletin No. 176 is descriptive of "Varitronic" electronic variable speed motor drive unit which is available in sizes up to 500 horsepower. Equipment makes it possible to operate direct current motor at any required speed directly from alternating current, single or 3-phase power lines. Also described are tubeless motor controls, high frequency induction and static heating units, and special electronic controls.

31. Precision Lofting

Template Reproduction Co.—16-page illustrated bulletin on "Precision Lofting" describes this short cut to industrial design, engineering, tooling and production. Extension of lofting practice to industrial applications affords speed, economy and accuracy. Typical uses include reproductions for identical right and left hand parts, making mock-ups, producing templates and fixtures, making linen copies and speeding assembly. Possibilities of process are shown.

32. Insulating Tape

Irvington Varnish & Insulator Co.—1-page illustrated data sheet outlines properties of "Fibron" tape which is designed for insulating wires, cables, and electrical equipment. This flexible elastic Vinylite resin tape is heat sealing, flame resistant, high in dielectric strength, strong mechanically and highly resistant to oils, acids, alkalies and moisture and normal variations of temperature and climate. Tape is also useful in protecting equipment, wiring or piping from corrosive or other conditions.

33. Chilling Machine

Deepfreeze Div., Motor Products Corp.—24-page illustrated "Metal Chilling Data Book" contains data and operational information for "Deepfreeze" industrial chilling equipment as applied to shrinking, testing and treating of metals. Specifications are given for various sizes of industrial machines for producing temperatures as low as minus 120 degrees Fahr. Technical data on industrial chilling and related engineering are included.

34. Friction Materials

S. K. Wellman Co.—4-page illustrated folder "More Miles With Velvetouch" discusses characteristics of this all-metal friction material which is designed for brake and clutch applications in all types of commercial and industrial equipment. Features of this material are outlined and typical applications shown.

35. Tool Steel Castings

Jessop Steel Co.—12-page illustrated bulletin on "Cast-To-Shape Jessop Steels" is addressed to users of dies, forming tools, gages, hobs and other similar parts. Tool steels are melted under rapid chemical and metallurgical control in induction furnaces and are cast to specific shapes for wide variety of applications. Typical parts and available alloys are shown.

36. Centralized Lubrication

Farval Corp.—16-page illustrated bulletin No. 25 is descriptive of "Farval" centralized systems of lubrication which provide correct amount of lubricant to every bearing surface in all types of machines and equipment. System is easily installed. Operation, operating elements, fittings and accessories are discussed.

37. V-Belt Drives

B. F. Goodrich Co.—44-page illustrated handbook of "Industrial Fractional Horsepower V-Belt Drives" provides guidance for proper selection of V-belt drives. Formulas, horsepower ratings and general engineering data are given on large selection of drives using pressed steel and cast iron single groove sheaves and adjustable cast iron single groove sheaves.

38. Precision Castings

Briggs Mfg. Co.—8-page illustrated bulletin entitled "Plaster Mold Castings by Briggs" explains production technique and possibilities of this method for producing precision castings for machine elements. Composition and properties of brass, bronze and aluminum alloys which are used in this casting method are given.

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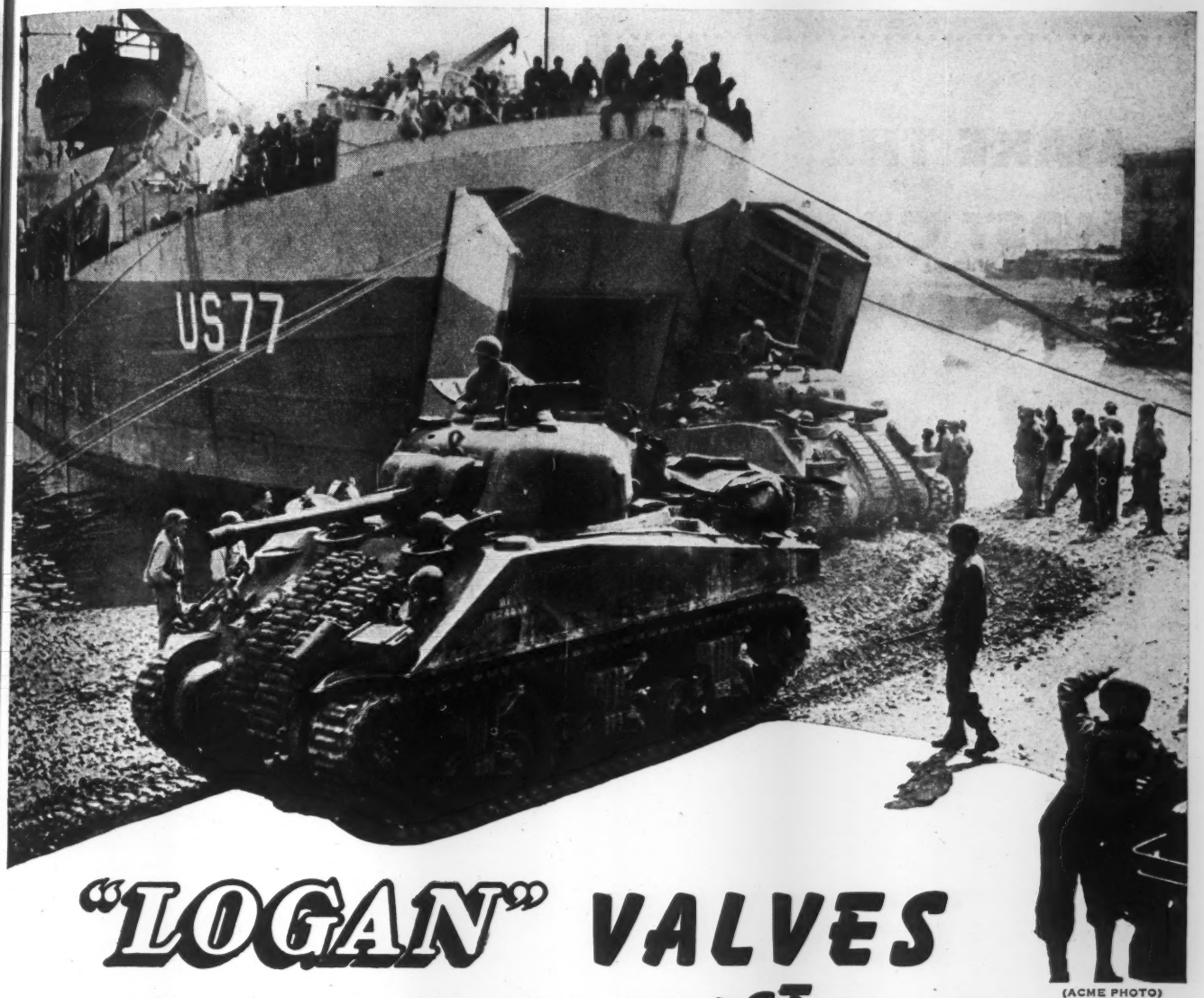

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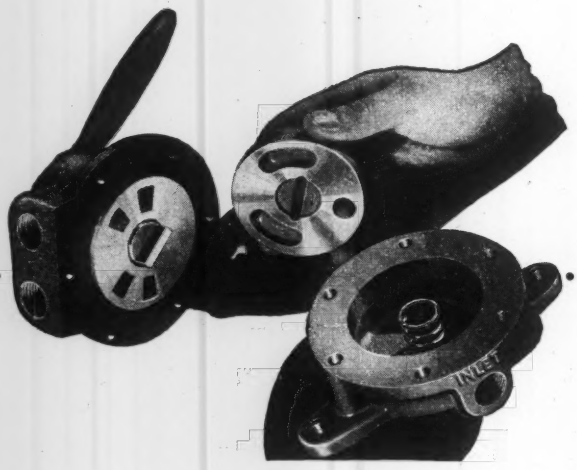

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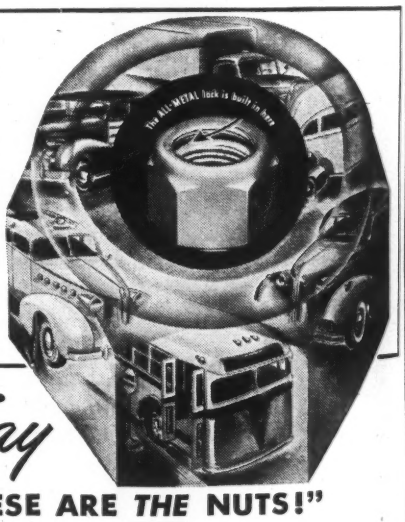
*Operators of 110,000 vehicles indicated in this survey that if a vibration-proof nut like the Boots were standard on their post-war equipment, tens of thousands of dollars for maintenance and repairs would be saved.



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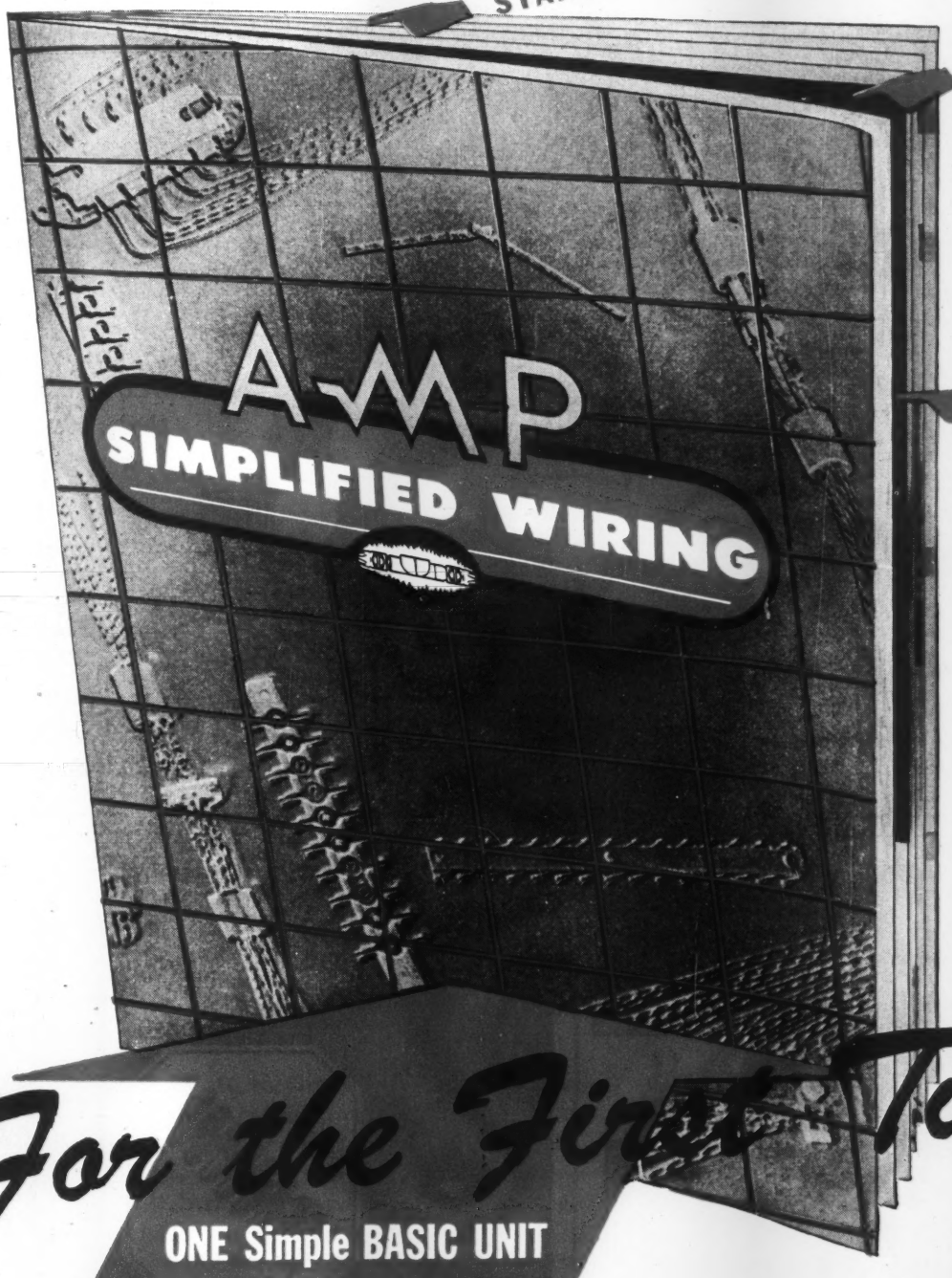

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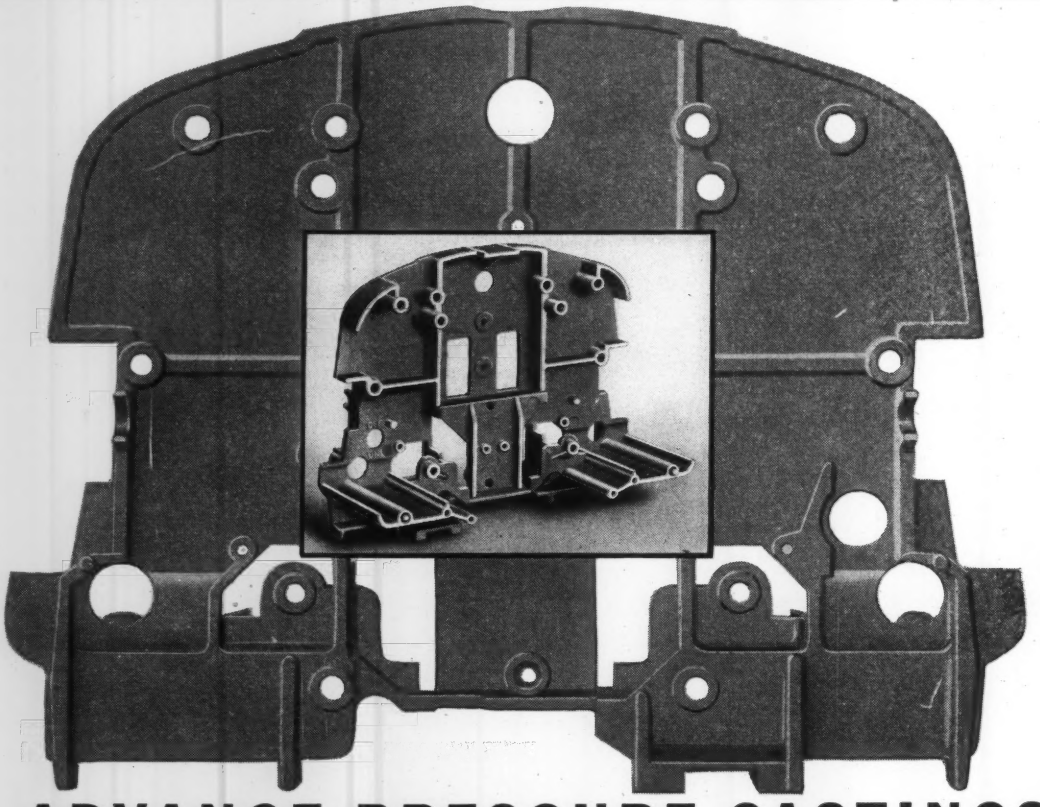

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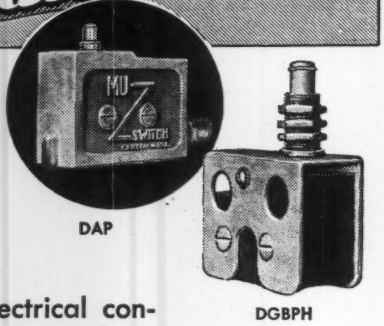

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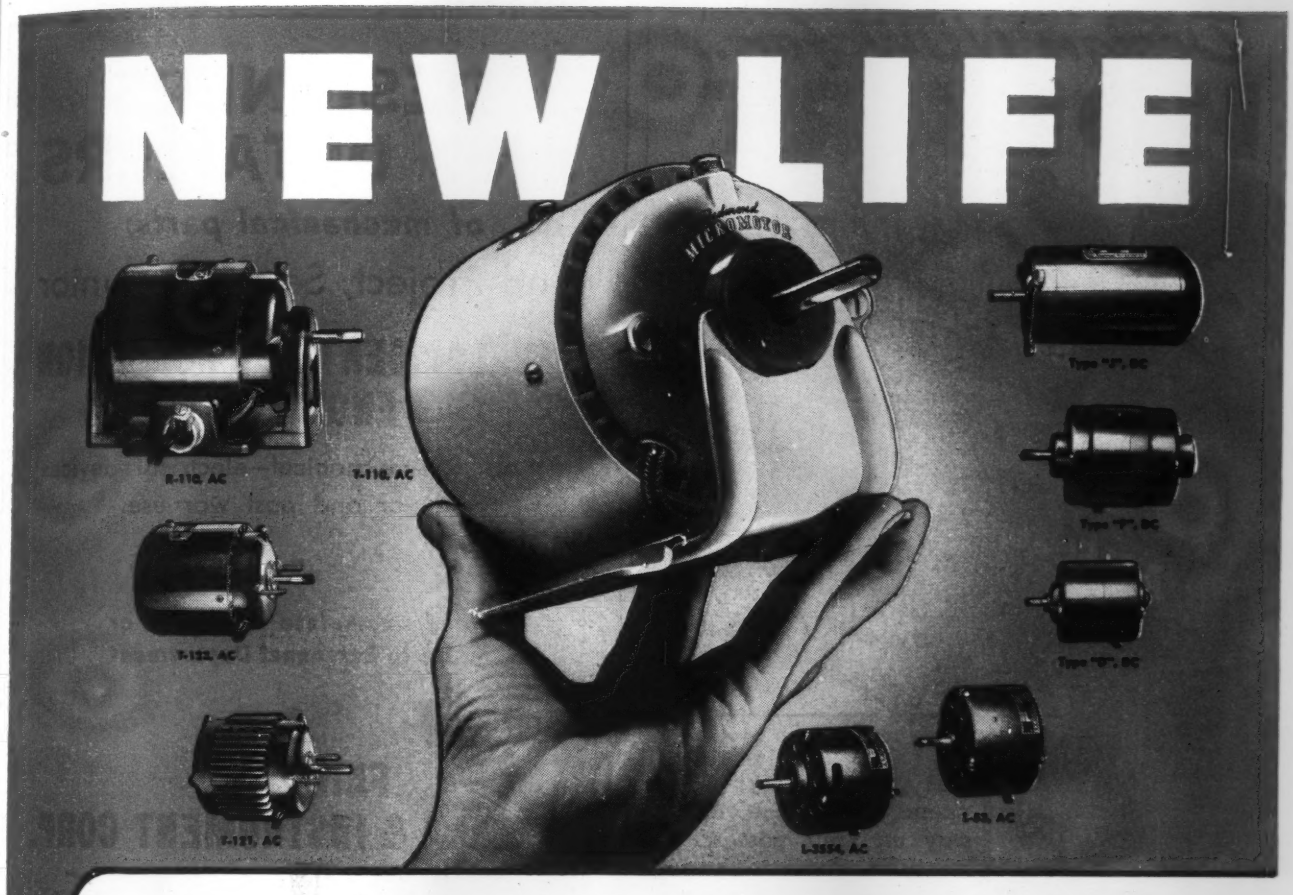

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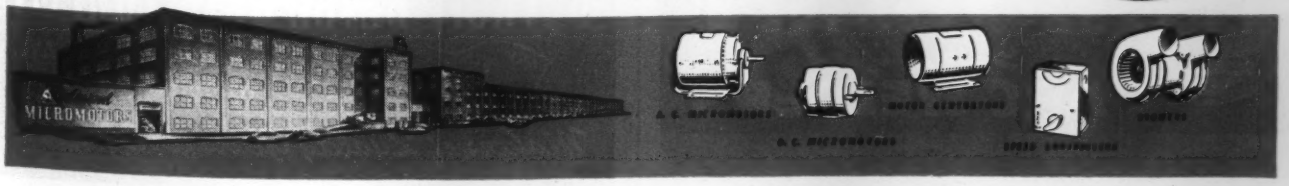

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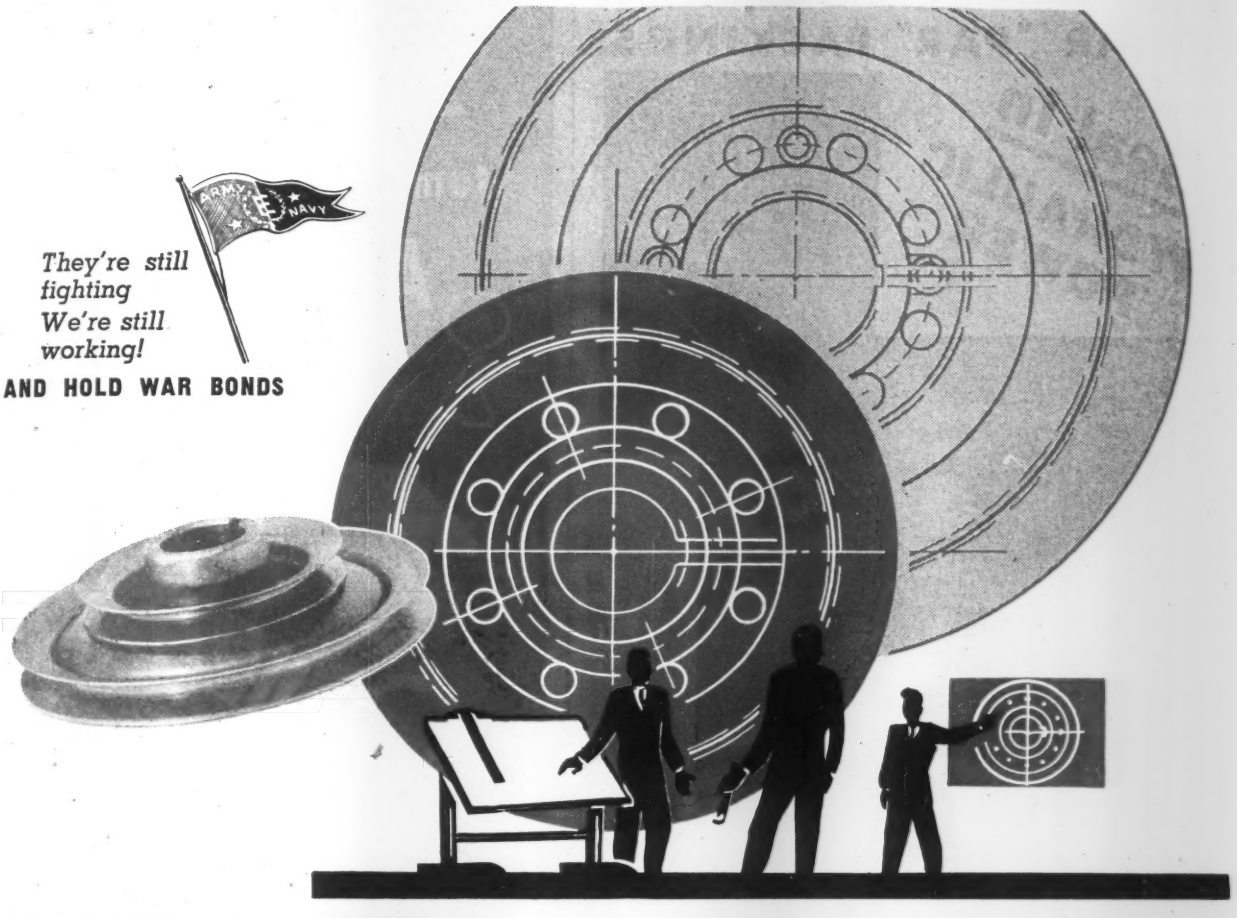

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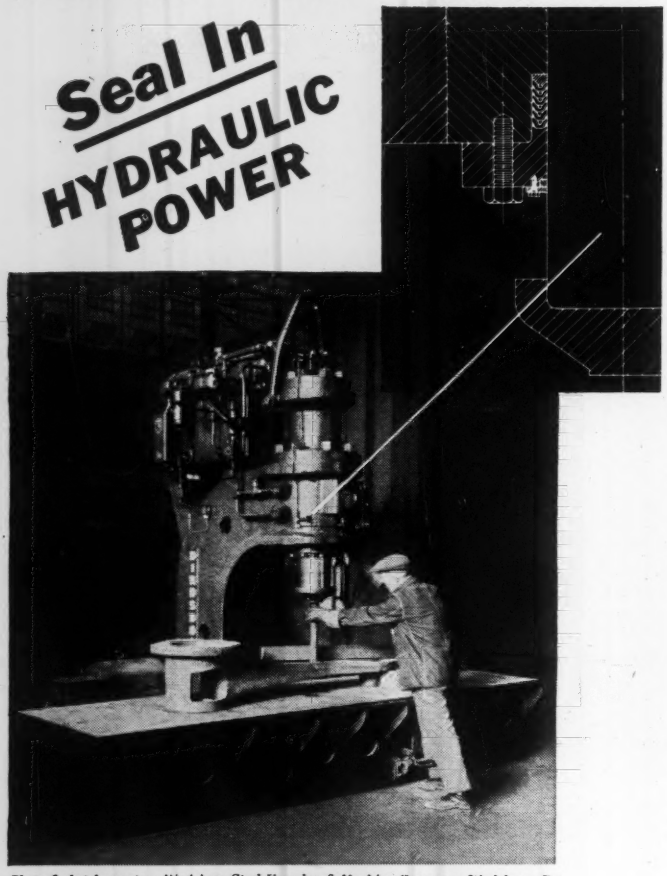

Photo & sketch courtesy Birdsboro Steel Foundry & Machine Company, Birdsboro, Pa.

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Linear "Par" packings effectively seal in the vital hydraulic power from source to point of application. All the power produced by the press is delivered at the ram aided by Linear's fluid-tight, thoroughly dependable seal . . . the seal which is the direct result of Linear "Par" packing's precision design, exacting production and meticulous inspection.

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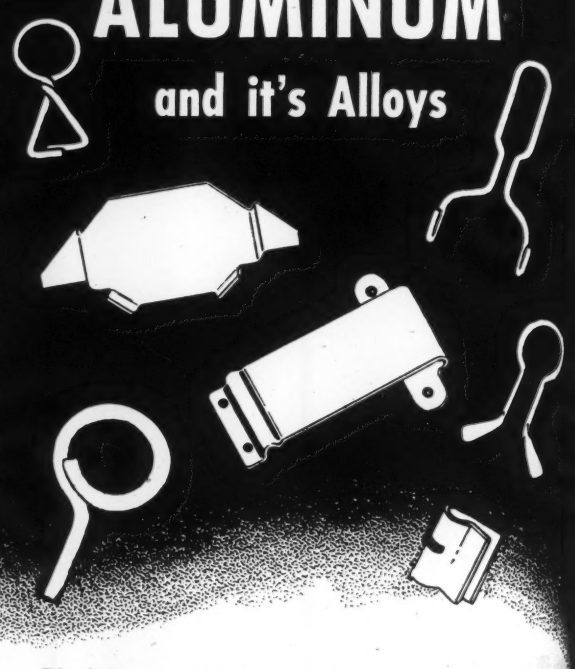

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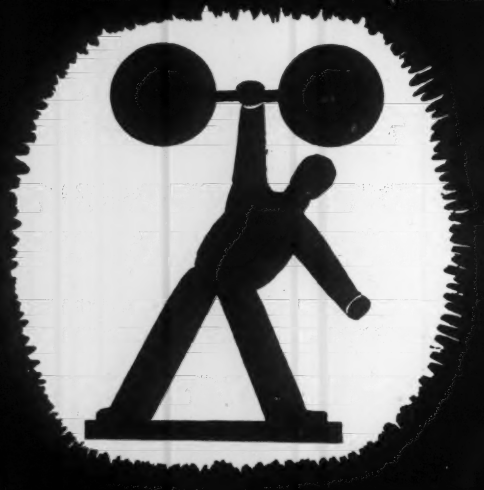

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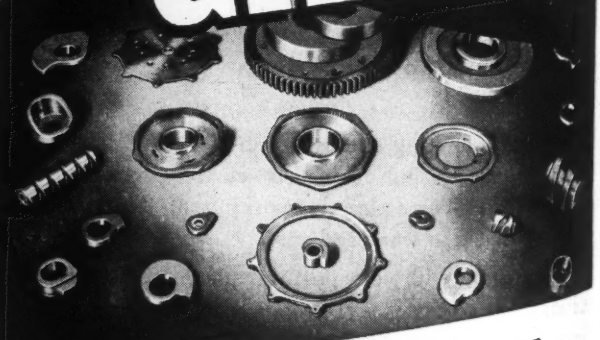

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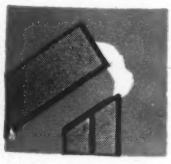
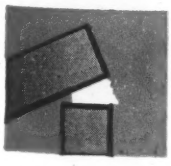
arcs leave this point Fast!

A POINT TO REMEMBER!



LIKE THIS. Diamond-pointed break jaws confine arcing to the point . . . force the arc to break outside the current carrying area. Contact surfaces stay clean . . . don't pit, don't burn.



NOT LIKE THIS. When ordinary safety switches are opened, the arc leaps across the contact areas . . . along the jaws and blade. It hangs on longer, burns and pits the contact surfaces.

When arcs hang fire, switch contacts become pitted and burnt . . . cause trouble. To avoid this, keep the arc away from the contact area—*and* put it out *quick!*

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For 575 or 600-volt circuits, Westinghouse provides extra protection—the exclusive "De-ion" arc quencher. Arcs are drawn into the grid chamber—divided—quenched quickly!

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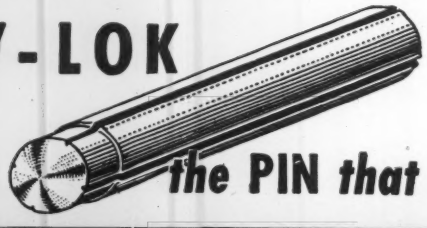
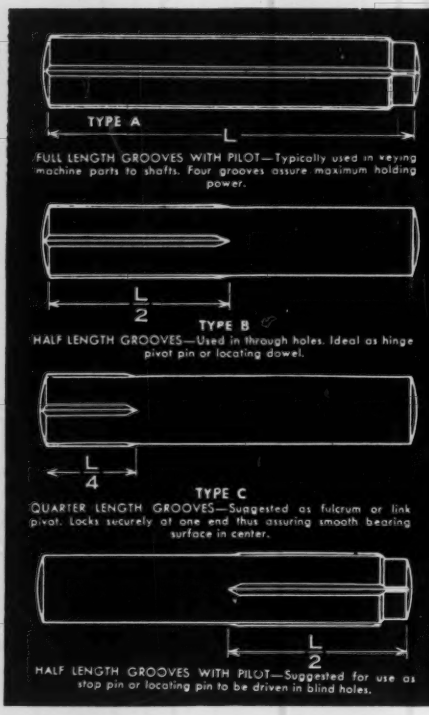


the PIN *that* LOCKS



Also Special Designs to Meet Specific Requirements

Will not Loosen --Vibration Proof

DRIV-LOK Pins answer "a hundred" connecting and anchoring problems, for driving into a standard hole; they will not loosen even under continuous vibration or repeated shock.

With bodies of specified diameters, each has four flutes with raised (oversize) edges along its binding or anchoring section. When driven into a drilled hole, these work hardened edges are slightly compressed. This deformation creates a steady and unyielding outward pressure of the flute edges against the walls of the hole.

DRIV-LOK pins come (standard) in type illustrated and in many special designs, in many materials and diameters. All can be delivered promptly.

To date our capacity has been taken for war requirements, but since we have no reconversion problems, we are ready at any time to deliver a few test samples or millions for post war production. *Write for Catalog.*

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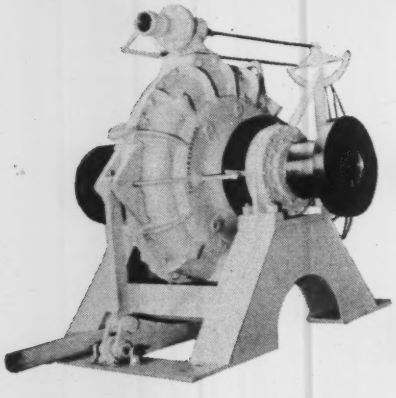

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The Parkersburg HYDROTARDER, the unique means of absorbing power through fluid friction, is now applicable as dynamometers for a wide range of applications. The HYDROTARDER dissipates power . . . or controls speed by absorbing power . . . on any type of rotating equipment requiring brakes. Fluid friction alone creates the resistance. No mechanical wear. Only one part moves. Does not operate under pressure.

The HYDROTARDER is now successfully used as engine dynamometers, as engine expansion brake, motor vehicle brake, tension reel or roll brake, decelleration brake, running in brake, and other industrial braking services.

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SOON!

It's our ONE customer—Uncle Sam, but we know in losing him we won't be out of business. When private enterprise is in the driver's seat again and with the experience gained in war production, we are prepared to produce forgings more economically and much better. Put us on your list of people to talk to for peace-time business, we'll be ready.

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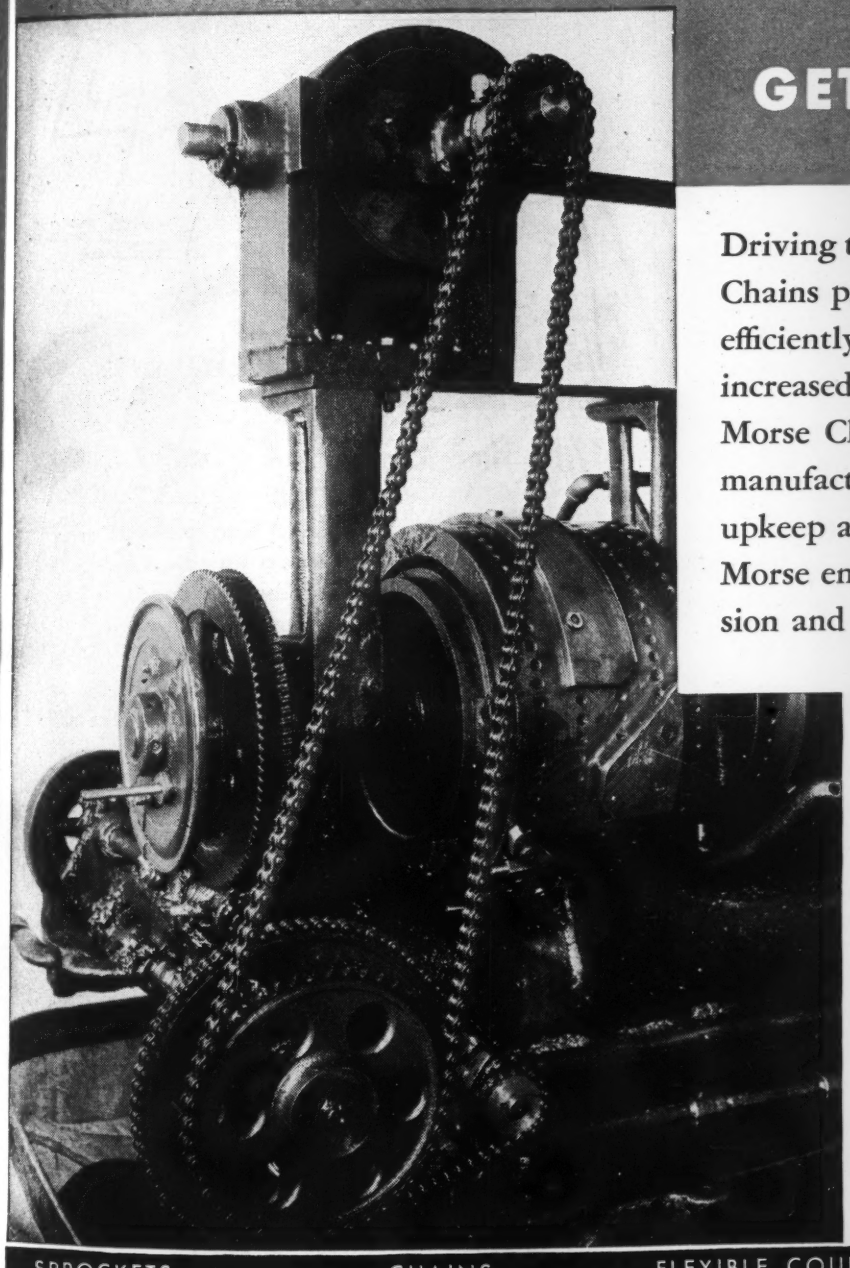
It's the Principle . . .

NO SLIP . . .

THAT GETS RESULTS!



Driving through teeth, not tension, Morse Chains prevent slippage, transmit power efficiently and economically. "Production increased 25% with the installation of Morse Chains"—says one machine parts manufacturer. Save substantially in time, upkeep and replacement costs—consult a Morse engineer on *your* power transmission and control problems.

SPROCKETS CHAINS FLEXIBLE COUPLINGS CLUTCHES

MORSE Roller and Silent CHAINS

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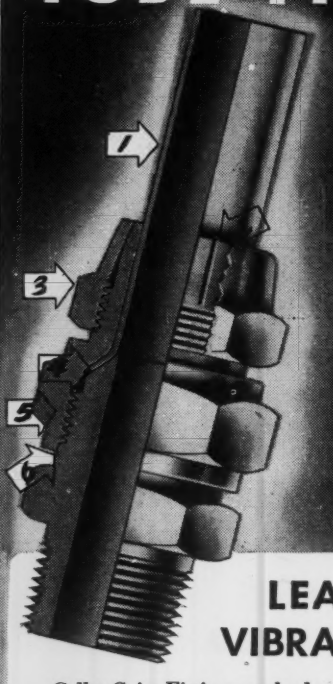
THAN THE TUBING ITSELF

COLLET GRIP
Seals as it grips

TUBE FITTINGS



1 Permit use of tubing in wide range of wall thicknesses.

2 SLOTTED collet insures uniform grip of tubing surface, protecting flare seal.

3 COMPRESSION NUT compresses Collet Nut to tube, forming permanent collet grip that cannot loosen.

4 DESIGN directs pulling stresses and vibration strains away from angle of flare.

5 COLLET NUT has long bearing surface which grips tube securely beyond the flare.

6 Easy to assemble and disassemble. Use repeatedly.

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Collet Grip Fittings embody a unique design principle that eliminates transmission of vibration and shock to tube connections—actually resulting in connections stronger than the tubing itself. This means leak-proof connections, and long, trouble-free service. Quickly installed, *Collet Grip Fittings* may be used over and over again—easily assembled or disassembled simply by tightening or loosening the compression nut. No threading, welding or soldering necessary. *Collet Grip Fittings* are now standard equipment in many of the nation's leading industrial plants. Write for Catalog No. 43 containing complete technical data.

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Flexible Metal Hose for Every Industrial Use

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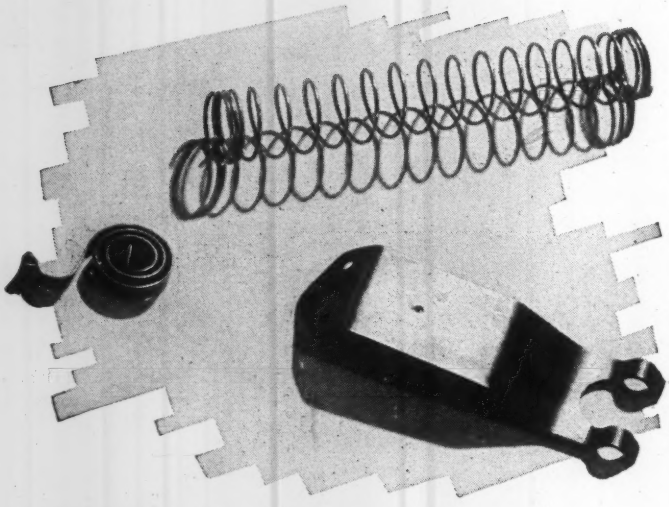

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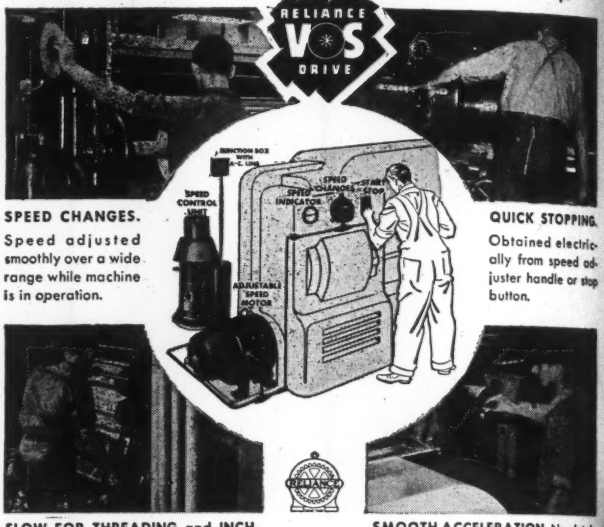

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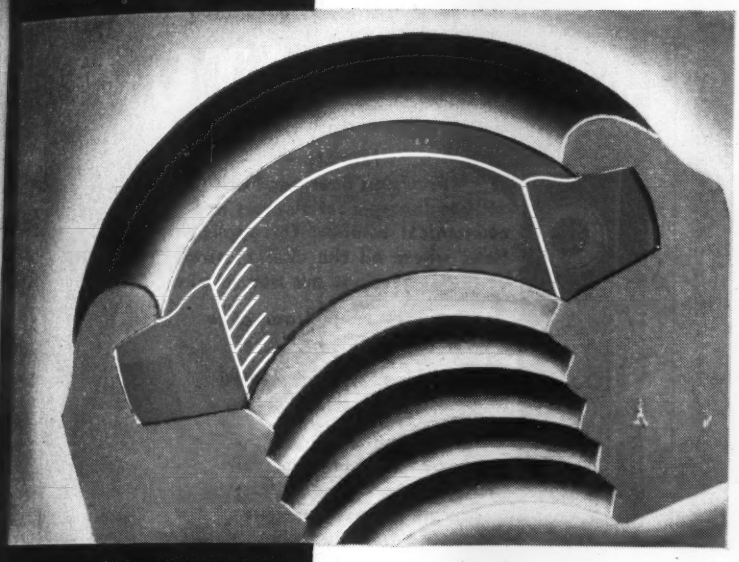

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So simple . . . so easy to apply . . . YET so powerful in their unshakeable locking grip! They're 100% secure against every conceivable vibration. BEST OF ALL, an ordinary wrench unclamps them again in an instant.

MEET AIRCRAFT REQUIREMENTS. Small but strong . . . absolutely tight against intense vibration . . . quickly removed and replaced during ground service . . . GREER Red Center Self-Locking Nuts have proven ideal.

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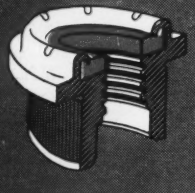
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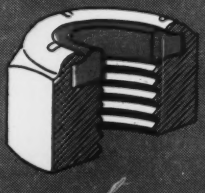
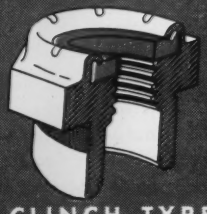
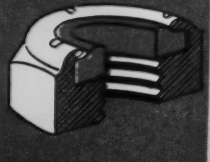

STANDARD


CLINCH TYPE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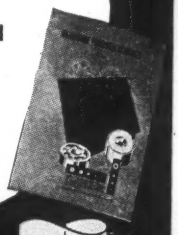

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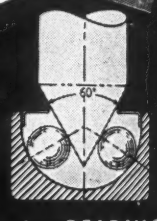

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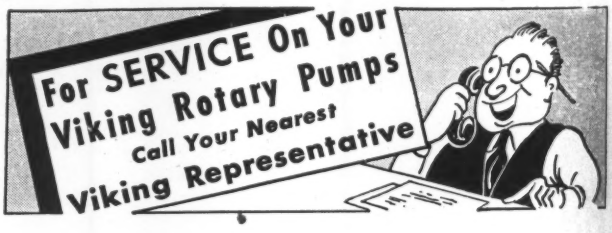

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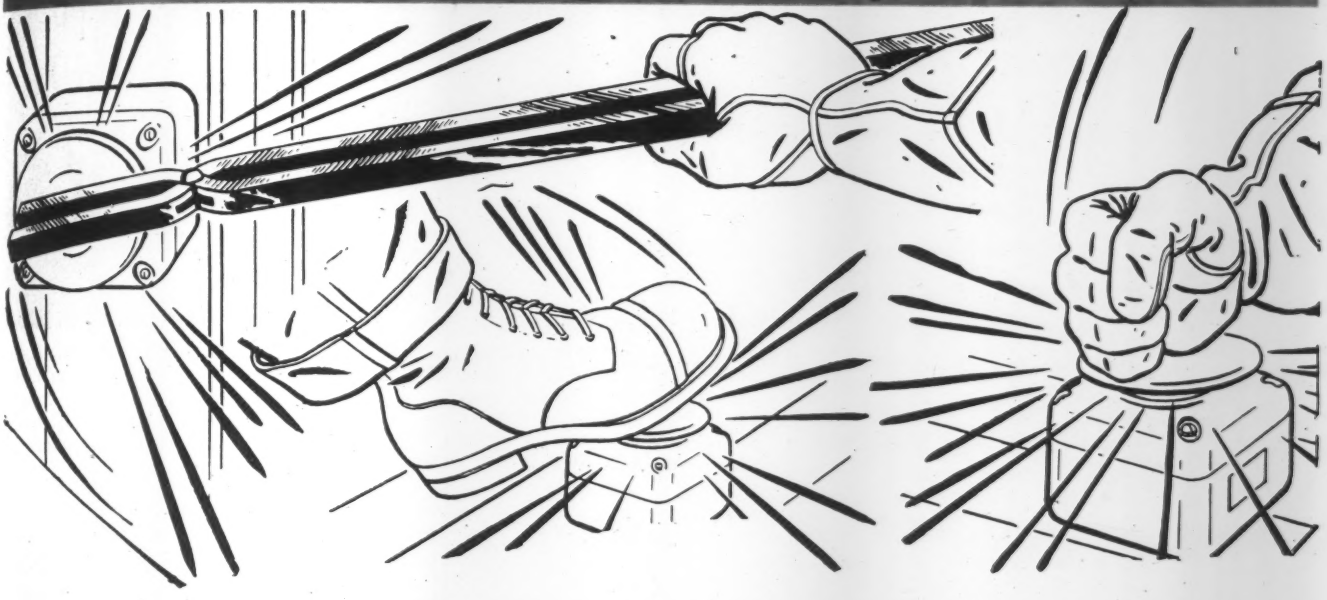

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OF THE "3C"
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The ROUGHNECK is built like "MR. FIVE BY FIVE"—low, squatty, and hugs the ground. There's plenty of bearing area, so that "off center" blows don't rock it on its base.

And if you miss the "button", those rounded sloping shoulders let the impact slide smoothly off.

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Large electrical clearances.

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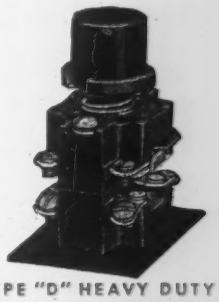

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What a boom we were handed by World War No. 1! Money came easily —went easily. Everybody was splurging on everything—from silk underwear to diamond sunbursts. Prices went skying. Sugar eventually hit 28¢ a pound!

Bye-bye, boom. Factories closed; men laid off. Prices and wages sinking fast. Wish we'd banked some of that dough we'd blown a few years back! With jobs scarce, that money would have come in mighty handy, then.

Prosperity. Stocks up fifty points in a week. Again everybody was buying everything—yachts, jewelry, stocks, real estate, regardless of cost. Depression? Phooey . . . we thought we'd found a way to lick depression.

Or had we? Bread lines, apple venders. WPA. "Brother, can you spare a dime?" No jobs. Prices dropping. Wages dropping. Everything dropping—except the mortgage on the house. "What goes up must come down."

We're splurging again. Americans have been earning more money. But even today there are fewer goods to spend it on—so naturally prices rise. We must keep them in check. DON'T LET *IT* ALL HAPPEN AGAIN!

---

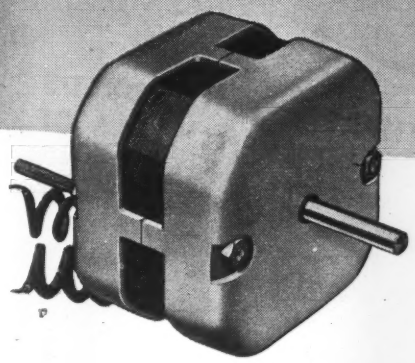
4 THINGS TO DO to keep prices down and help avoid another depression

1. Buy only what you really need.
2. When you buy, pay no more than the ceiling prices. Pay your ration points in full.
3. Keep your *own* prices down. Don't take advantage of war conditions to ask for more—for your labor, your services, or the goods you sell.
4. *Save.* Buy and hold all the War Bonds you can afford—to help pay for the war and insure your future. Keep up your insurance.

A United States War message prepared by the War Advertising Council; approved by the Office of War Information; and contributed by this magazine in co-operation with the Magazine Publishers of America.

Moistureproof

EMC FRACTIONAL H.P. MOTOR NOT AFFECTED BY HIGH HUMIDITY CONDITIONS



The EMC moistureproof, rustproof fractional H. P. motor, illustrated, serves industry in many different and unusual ways—particulary where high humidity or direct moisture are factors.

One such application is the refrigerated commercial display case, used in butcher shops and stores. Manufacturers secure higher efficiency from condenser units by installation of a fan to cool down the condenser. Powering this small fan is a tiny EMC No. 800 1/100th H. P. motor. Rustproof, moistureproof, this motor requires absolutely no attention, and gives trouble-free service, even under these high humidity conditions.

Perhaps you have a similar problem that can be effectively solved by a special EMC Fractional H.P. Motor. Our motors range in size from "flea" power to 1/15th h. p. and are available with any one of thirteen separate gear reducers. Write for special SERVICE SHEET to obtain details on motor equipment for your need.

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stockades used cross-bars...

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To bring out the best in those new designs, you may need a fastener that has yet to be invented . . . a fastener that enables your product to do a better job.

Millions of Camloc quick-acting fasteners serve the aircraft industry on all fronts. Camloc designs fasteners to fit *precise* needs, and the accumulated knowledge and valuable experience that solved aircraft's fastener problems is at your service.

Whether you plan to make radios or vacuum cleaners, automobiles or washing machines, you'll find Camloc has much to offer.

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By Joseph Marin

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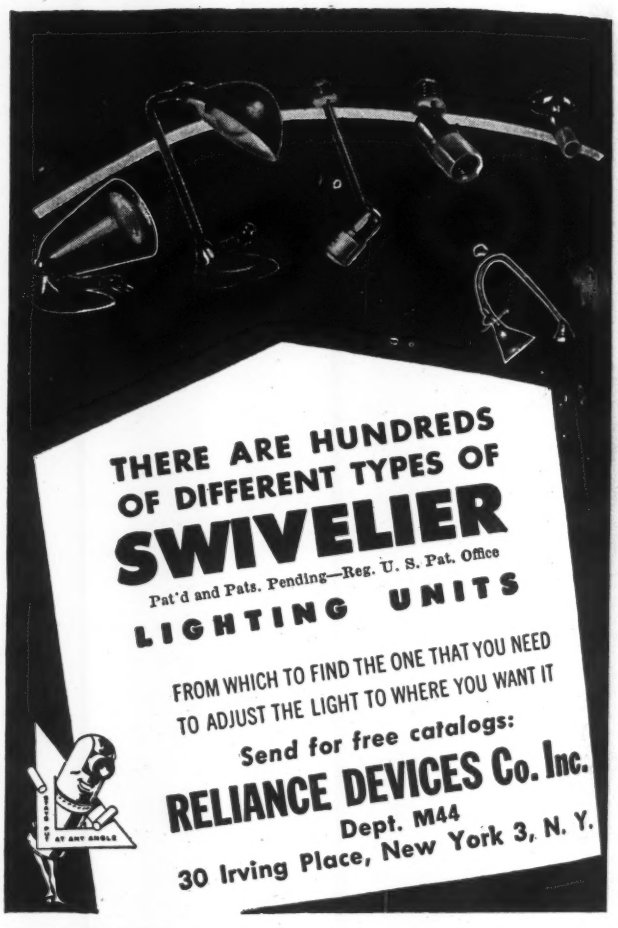

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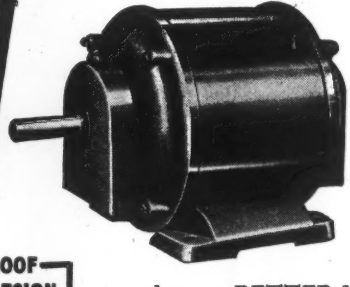

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Valley Ball-Bearing Motors are designed to meet operating conditions where hazards of liquids, chips, etc., dropping into the motor, are involved. Motors are protected against this as well as against normal splash conditions.

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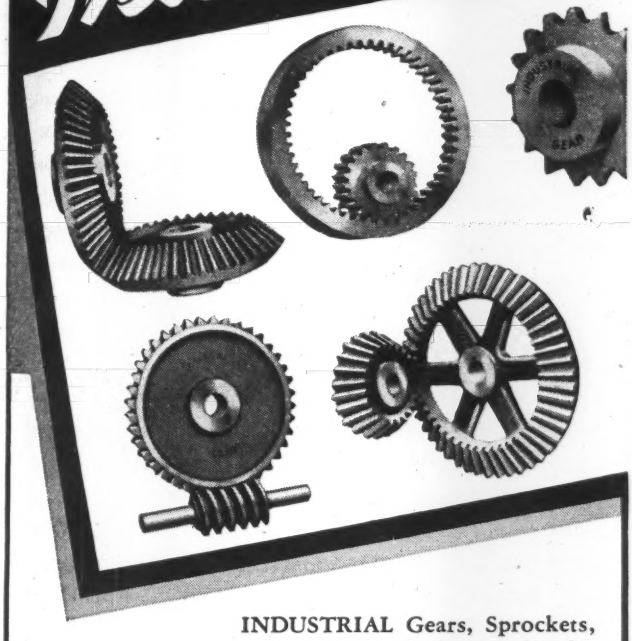

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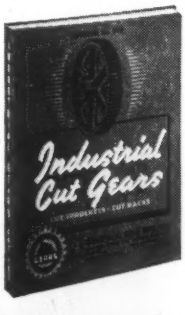

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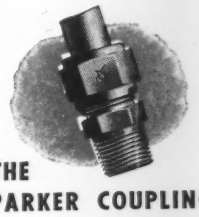

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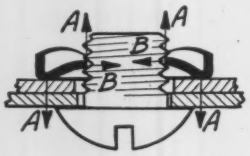

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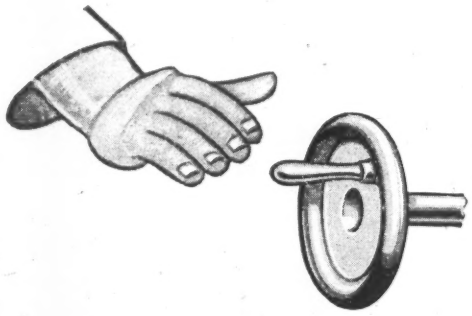

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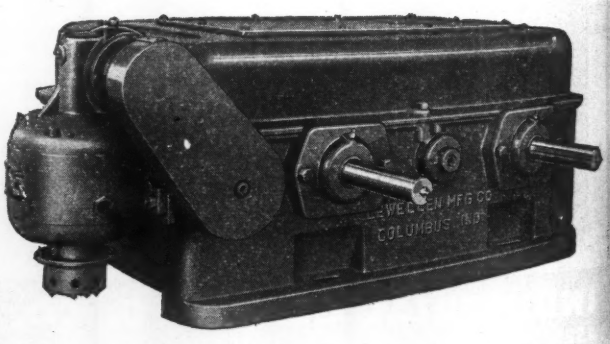

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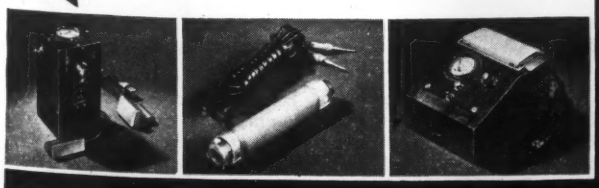

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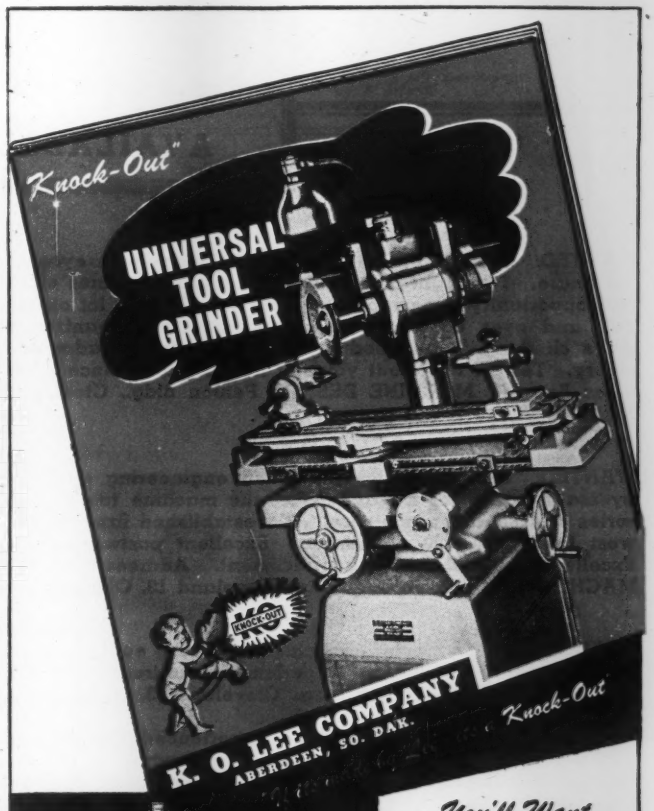

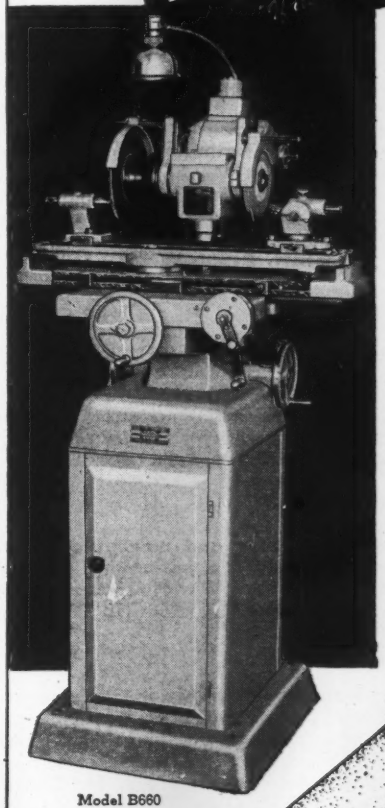

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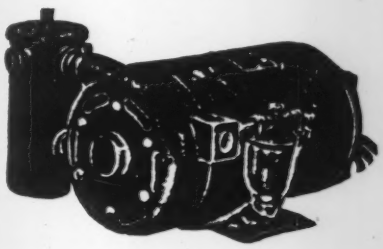

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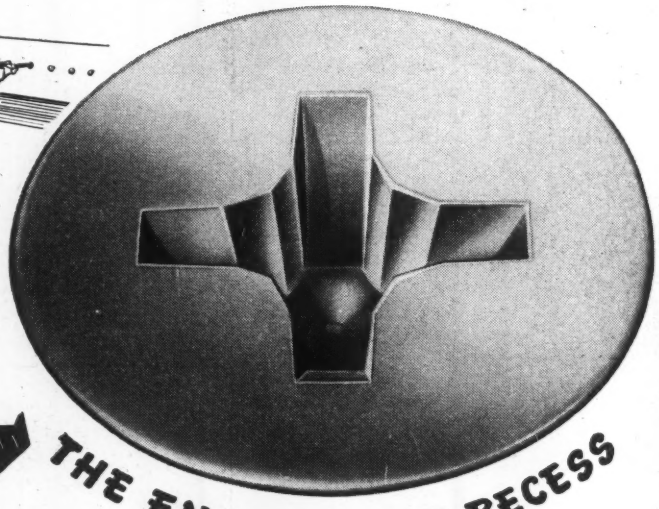

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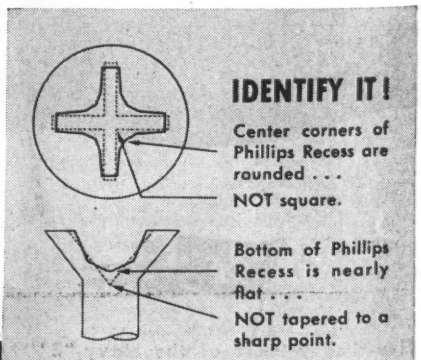

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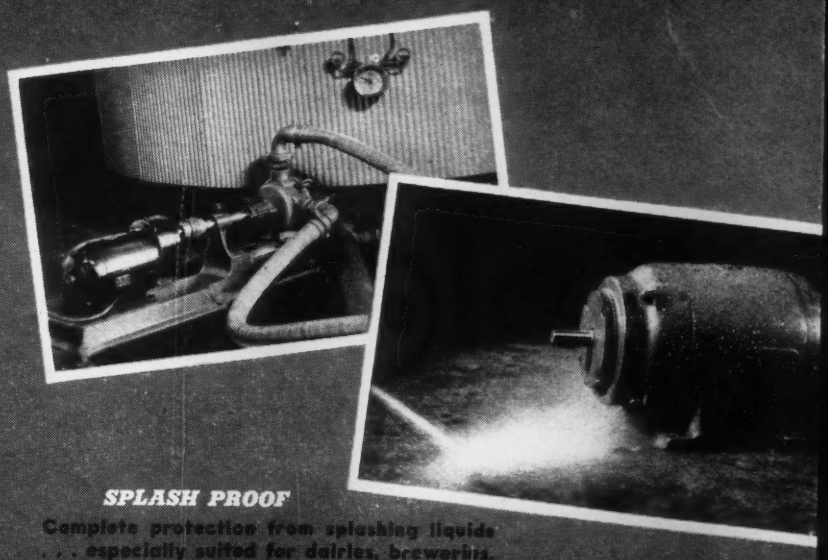

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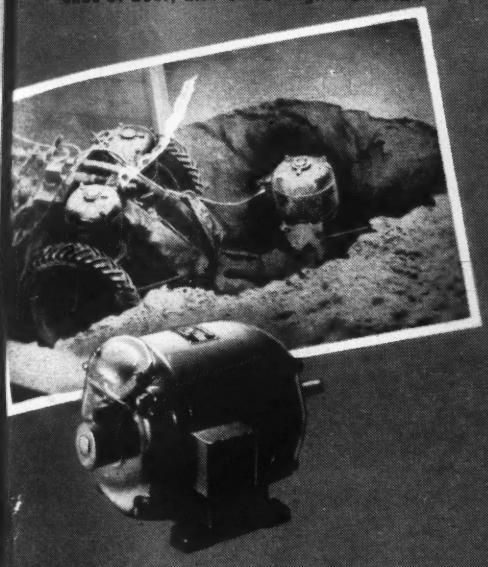

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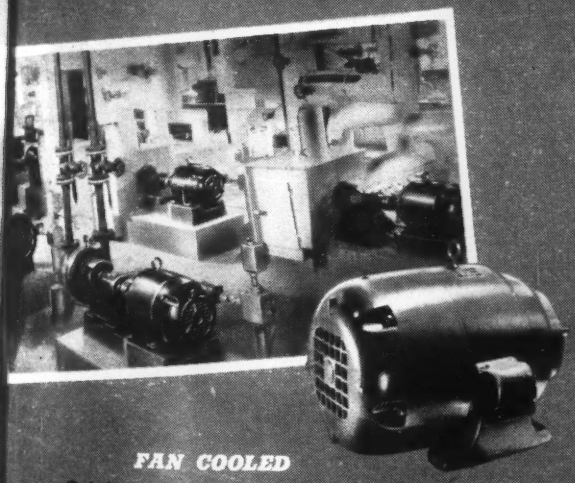

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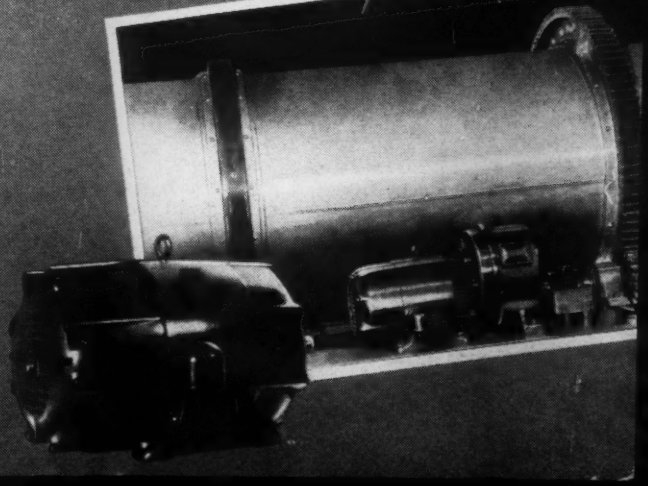

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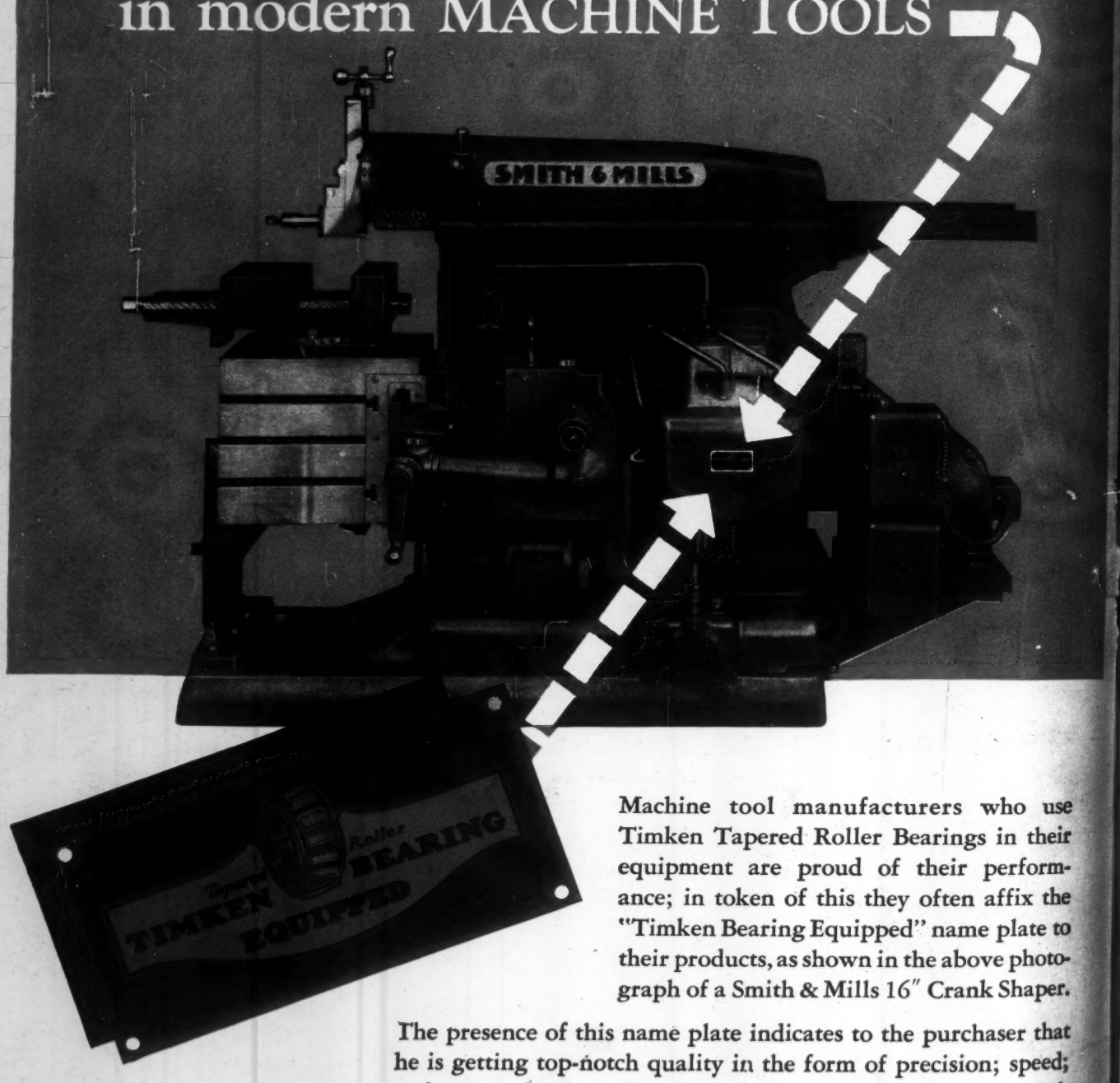

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